

SCALPELLID BARNACLES (CIRRIPEDIA: THORACICA)  
FROM THE NORTHEASTERN AND CENTRAL EASTERN AUSTRALIAN  
CONTINENTAL SHELF AND SLOPE

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Eleven species of scalpellid barnacles are described from continental shelf and slope waters off northeastern and central eastern Australia. Nine of these species were collected by the Cidaris I expedition which sampled barnacles mainly from the continental slope of northeastern Queensland and the adjacent Coral Sea. The additional two scalpellid species were contained in the deep-water cirripede collections of the Queensland Museum, Brisbane, and the Australian Museum, Sydney. The species are fully described and illustrated since previous descriptions often have described conchology only and detailed descriptions, especially of arthropodal structures and of dwarf or complementary males, are either absent or are brief and inadequate. All the scalpellids collected by Cidaris I were first records from Queensland waters and, with the exceptions of *Verum australicum* Hoek and *Anguloscalpellum pedunculatum* (Hoek), first records from Australian waters. They were listed, but not described, in the recent catalogue of the Australian cirripede fauna (Jones et al., 1990). In the present contribution *Trianguloscalpellum hirsutum* sensu Jones et al. (1990) is regarded as a synonym of *T. hamulus* (Hoek). *T. hamulus* and *A. persona* are new records for Australian seas, and *S. stearnsii* is recorded from Queensland for the first time. □ *Crustacea, Thoracica, Lepadomorpha, Scalpellidae, Australia, new records, taxonomy.*

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Documentation of the littoral and shallow water cirripede fauna of Australia began during the French expeditions of discovery at the beginning of the nineteenth century (Jones, 1991). The first contributions towards knowledge of the deeper water Australian cirripede faunas were not made until the late nineteenth and early twentieth centuries and are contained in Hoek's reports on the Cirripedia collected during the voyages of 'Challenger', between 1873 and 1876, and 'Siboga', from 1899 to 1900 (Hoek, 1883, 1907, 1913). Subsequently significant contributions have been made through the works of Calman (1918, 1919), Nilsson-Cantell (1927, 1928), Newman (1960), Utinomi (1968), Foster (1981) and Zevina (1981a). More recently, documentation of Australian shelf and slope (as well as littoral) cirripede faunas has been completed (Jones et al., 1990).

The Cidaris I expedition, which sampled the deep-sea fauna of the Coral Sea, was organised by the James Cook University of North Queensland, Townsville, in 1986. Some samples were obtained from the continental shelf and the majority from the continental slope and adjacent Coral Sea off the northeastern Queensland coast, out from Townsville (19°16'S, 146°49'E), at depths of 287

to 1612m. The present report covers the nine species of scalpellid barnacles collected by this expedition and further reports will cover the remaining lepadomorphs and the Verrucomorpha and Balanomorpha collected during the expedition. On examination of the deep-water barnacle collections housed in the Queensland Museum, Brisbane, and the Australian Museum, Sydney, two further scalpellid species were discovered that had been collected from the waters of the northeastern and central eastern Australian continental slope. For comparative purposes, slope material from northwestern Australia housed in the Western Australian Museum, Perth, was utilized to validate identifications. Where relevant this material has also been included in the present contribution.

Eleven continental shelf and slope scalpellids are described and illustrated. Supplementary descriptions of each species, especially of arthropodal structures and dwarf and complementary males, are given since these have either not been described previously, or existing descriptions are brief or inadequate. The classification and sequence used for the Scalpellidae is that of Zevina (1981a, 1982). All measurements are in centimetres.

Abbreviations: AM, Australian Museum, Sydney; QM, Queensland Museum, Brisbane; WAM, Western Australian Museum, Perth; CH, capitular height; CW, capitular width; PL, peduncular length; PW, peduncular width; R, range; (R) right; (L) left. Registration numbers of AM material are prefixed by P, QM material by W (with *Cidaris* I material indicated by W\*) and WAM material by WAM.

#### LIST OF THE SPECIES

1. *Scalpellum stearnsii* Pilsbry, 1890
  - \*2. *Alcockianum alcockianum* (Annandale, 1905)
  3. *Alcockianum persona* (Annandale, 1916)
  - \*4. *Annandaleum lambda* (Annandale, 1910)
  - \*5. *Verum australicum* (Hoek, 1883)
  - \*6. *Anguloscalpellum pedunculatum* (Hoek, 1883)
  - \*7. *Amigdoscalpellum daschae* Zevina, 1981
  - \*8. *Amigdoscalpellum elegans* (Hoek, 1907)
  - \*9. *Trianguloscalpellum hamulus* (Hoek, 1907)
  - \*10. *Arcoscalpellum michelottianum* (Seguenza, 1876)
  - \*11. *Arcoscalpellum moluccanum* (Hoek, 1883)
- \*indicates material collected by *Cidaris* I.

*Trianguloscalpellum hirsutum* sensu Jones et al. (1990) is regarded as a synonym of *T. hamulus* (Hoek, 1907). *T. hamulus* and *A. persona* are new records from Australian seas, and *S. stearnsii* is recorded from Queensland waters for the first time.

#### SYSTEMATICS

Order THORACICA Darwin, 1854  
 Family SCALPELLIDAE Pilsbry, 1916  
 SCALPELLINAE Pilsbry, 1907  
*Scalpellum* Leach, 1817

*Scalpellum stearnsii* Pilsbry, 1890  
 (Figs 1, 2)

*Scalpellum magnum* Darwin, 1851: 18, pl. 1, fig. 1.  
*Scalpellum stearnsii*(i) Pilsbry, 1890a: 96; Pilsbry, 1890b: 441, fig.; Weltner, 1897: 250; Gruvel, 1905: 44, fig. 46; Pilsbry, 1907: 14, pl. 4, figs 1-5; Krüger, 1911: 18, figs 26-35, pl. 2, figs 18-19; Pilsbry, 1911: 61; Annandale, 1916b: 293; Broch, 1922: 235, fig. 6; Broch, 1931: 16; Hiro, 1933: 22, fig. 4, pl. 1 figs 5-5a; Nilsson-Cantell, 1933: 33; Newman & Ross, 1971: 123; Zevina 1981a: 98, fig. 68; Rosell, 1981: 279, pl. 1e; Ren, 1987: 189, fig. 1:1.

*Scalpellum calcariferum* Fischer, 1891: 116, fig.  
*Scalpellum inerme* Annandale, 1905: 75, fig. 1, pl. 8, figs 1-1a; 1909: 270; Pilsbry, 1907: 14.  
*Scalpellum stearnsii* var. *inerme*: Annandale, 1916b: 293; Nilsson-Cantell, 1928: 2, fig. 1; Broch, 1931: 17; Nilsson-Cantell, 1933: 33; 1934: 44, pl. 5 fig. 1.  
*Scalpellum stearnsii* var. *robusta* and var. *gemina* Hoek, 1907: 69, 70, pl. 6, figs 1-12; Pilsbry, 1911: 62; Weltner, 1922: 16.  
*Scalpellum stearnsii inerme*: Nilsson-Cantell, 1938: 8; Newman & Ross, 1971: 123.

#### TYPE LOCALITY

East coast of Japan, between the bay of Tokyo and the Inland Sea.

#### DISTRIBUTION

Indian Ocean, Malay Arch., Indonesia, northwestern Australia, South China Sea, Japan. Depth range 182-2117m. Now known from central eastern Australia (465-562m).

#### MATERIAL EXAMINED

W15533, S of Swain Reefs (23°28'S, 153°19'E), 562m, 1 spec.; W10196, 130km E of Capricorn Gp (23°28'S, 153°19'E), 562m, 15 specs; W1097, 100km E of Capricorn Gp (23°30'S, 153°04'E), 540m, 6 specs; W11303 (part), E of Bunker Gp (23°54'S, 153°01'E), 465m, 1 spec.; W14339 (27°20'S, 153°53'E), 600m, 1 spec.; P35288, E of Gold Coast (28°02'-27°59'S, 153°59'E), 540m, 1 spec.

#### DESCRIPTION

Large individuals female. Capitulum laterally compressed, fourteen capitular plates, calcareous, partially reduced. Carina angularly flexed, umbo at angle. Carinolatus with horn-like projection which is very variable, almost wanting to strongly developed, when free projecting portion can be one-third to one-half length of plate. Peduncle with prominent external rings of overlapping calcareous scales. Measurements of the 25 specimens: CH 1.75-4.93 (mean 3.28), CW 1.05-3.90 (mean 2.17), PL 1.43-12.85 (mean 4.23), PW 0.55-1.98 (mean 2.3).

Cirrus I with rami very unequal in length and shape, anterior ramus much shorter than posterior ramus, proximal and intermediate segments of anterior ramus very protuberant especially towards posterior, segments transversely oblong and only united with one another over part of breadth, segments of posterior ramus square. Cirri II and III elongated, rami subequal, bearing three to six pairs of long setae on anterior margins, anterior ramus of cirrus II more setose than

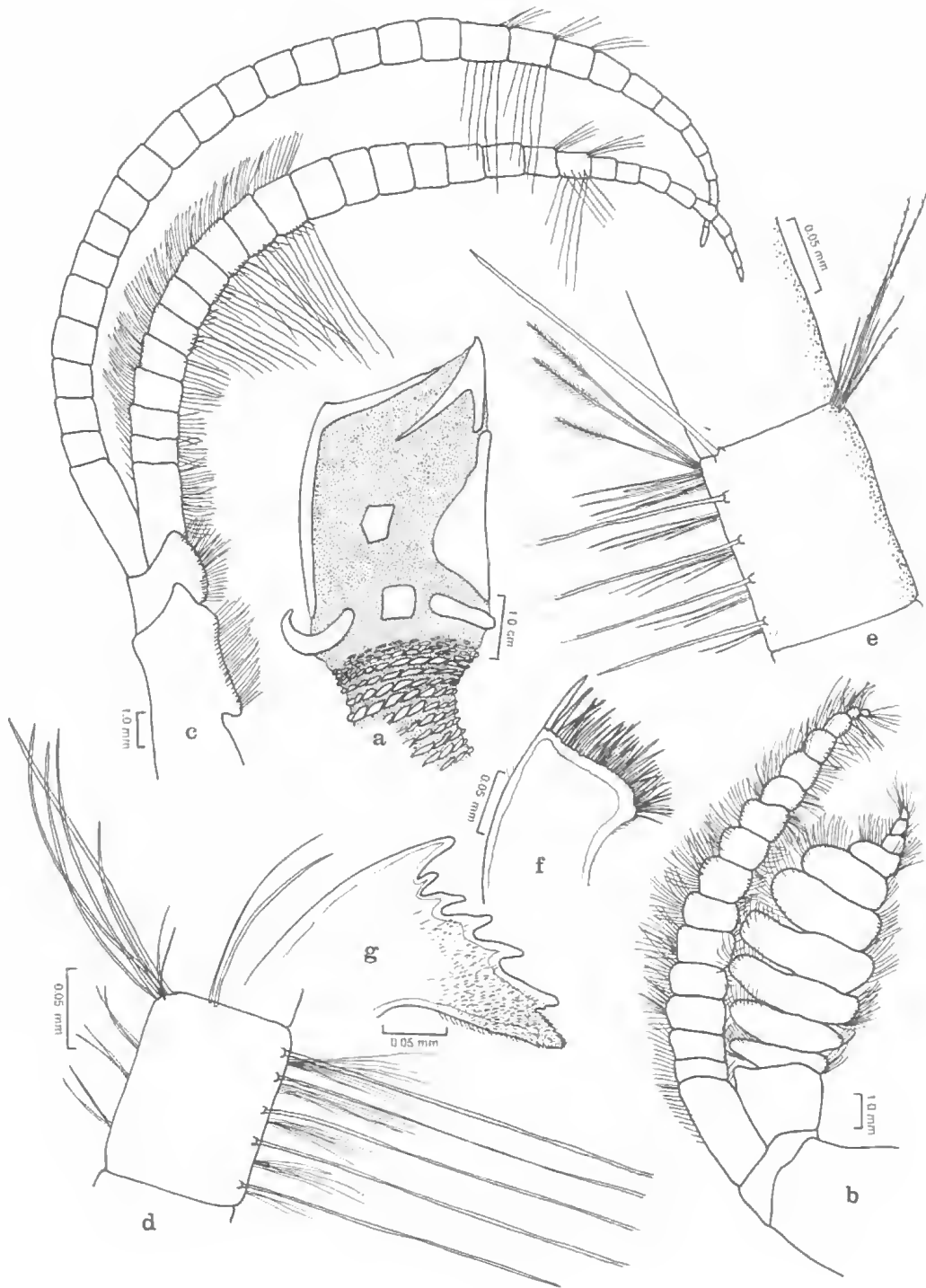


FIG. 1. *Scalpellum stearnsii* Pilsbry, 1890. a, lateral view. b, cirrus I. c, cirrus II. d, intermediate segments, anterior ramus, cirrus III. e, intermediate segments, anterior ramus, cirrus V. f, maxillule. g, mandible.

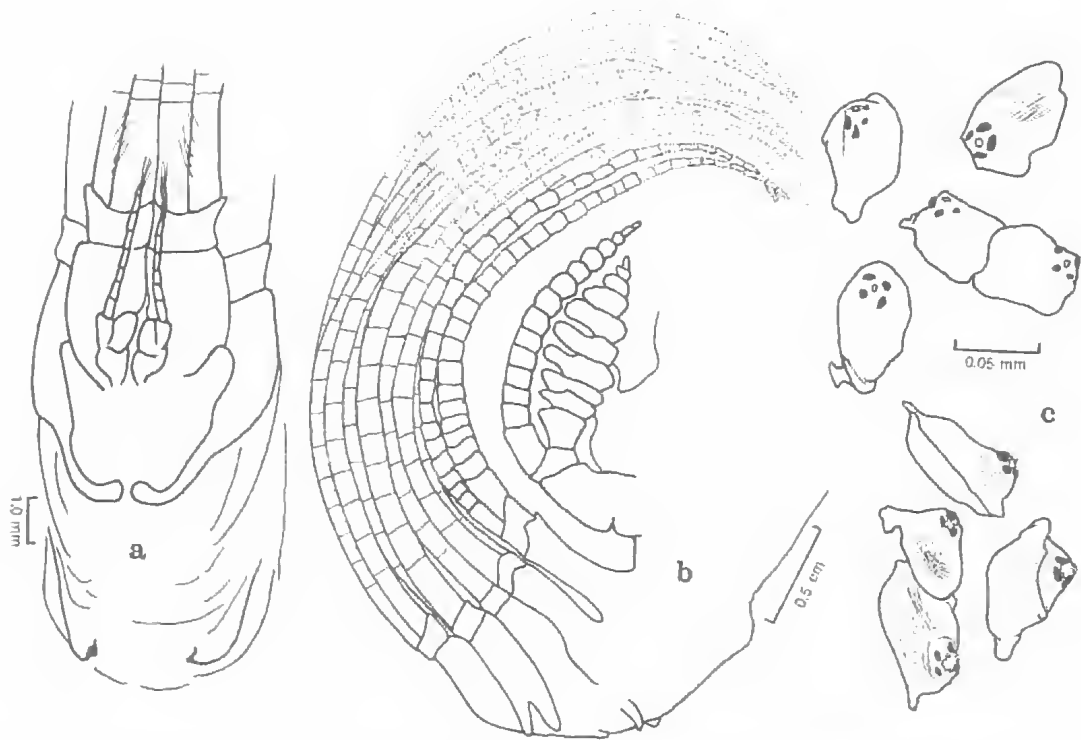


FIG. 2. *Scalpellum stearnsii* Pilsbry, 1890. a, posterior view, caudal appendages and pedicels of posterior cirri. b, lateral view of prosoma. c, dwarf males.

posterior ramus of cirrus II and both rami of cirrus III. Cirri IV, V and VI very long, rami subequal, segments elongated, bearing five to seven pairs long setae on anterior margins, posterior margins of proximal segments of cirri V and VI bearing dense scales, scales more numerous on anterior rami. Chaetotaxy ctenopod. Cirral formulae, see Table 1.

Maxillule with sinuous cutting edge bearing many setae (28-34 pairs), seta at upper angle stout and slightly larger than remainder. Mandible with five main teeth, simple, second smallest, subsidiary teeth may be present between main teeth, lower angle pectinate with short, chitinous hairs. Labrum strongly bullate, not cleft, teeth absent. Caudal appendages small, multi-articulate (6-10 segments), slightly longer than height of pedicel of cirrus VI, with tuft of long setae apically.

Dwarf males (8-10) at occludent margins of both scuta of female, located just above adductor muscle in deep pits in scutal membrane; sac-like, boat-shaped when viewed laterally, peduncle and capitulum not differentiated, four rudimentary, calcareous plates around subterminal orifice, short rudimentary tentacles between plates, body exter-

nally covered with minute erect spicules, two small, prehensile antennae on ventral surface.

#### REMARKS

The species has been reported from northwestern Australian waters (Jones et al., 1990) but not previously from eastern Australia. *S. stearnsii* is similar to *S. scalpellum* (Linnaeus) (= *S. vulgare* Leach) but the form of the carinolatera distinguishes *S. stearnsii*.

The species was first described from shallow water (11-18m), from the east coast of Japan (Pilsbry, 1890a,b). One year later Fischer (1891) described *S. calcariferum* from Sagami Bay, Japan, which later authors considered to be synonymous with *S. stearnsii* Pilsbry (Weltner, 1897; Gruvel, 1902). Fischer (1891) and Annandale (1909) also both pointed out the close resemblance between *S. stearnsii* Pilsbry and the fossil species *S. magnum* Darwin of the Coralline Crag, Sudbourne.

*S. inerme*, a species with highly degenerate capitular plates, was described from a depth of 293m from the Bali Straits (Annandale, 1905). Pilsbry (1907) considered *S. inerme* a distinct

TABLE 1. Measurements and cirral formulae of *Scalpellum stearnsii* Pilsbry, 1890.

CH	CW	PL	PW		CI	CII	CIII	CIV	CV	CVI	Ca
3.72	2.35	5.59	1.18	(R)	$\frac{11}{17}$	$\frac{25}{28}$	$\frac{31}{32}$	$\frac{30}{30}$	$\frac{30}{30}$	$\frac{33}{33}$	8
3.98	4.64	5.35	1.50	(R)	$\frac{11}{15}$	$\frac{30}{30}$	$\frac{33}{24+}$	$\frac{28+}{25+}$	$\frac{33+}{28+}$	$\frac{27+}{28+}$	10
4.76	3.08	6.87	1.70	(R)	$\frac{11}{16}$	$\frac{29}{29}$	$\frac{35}{24}$	$\frac{36}{34}$	$\frac{37}{35}$	$\frac{36}{35}$	10

species. Hoek (1907) established *S. stearnsii* var. *gemina*, which also had degenerate plates, and var. *robusta* which had a broader and longer capitulum than the typical form, from specimens collected by 'Siboga' in the Malay Archipelago at depths of 204-450 m. Pilsbry (1911) synonymized *S. stearnsii* var. *gemina* with *S. inerme*, but considered var. *robusta* identical with the typical form. However, Annandale (1916b), after examining a good series of specimens from Japan and the Malay Archipelago, considered *S. inerme* to be an extreme form of Hoek's var. *gemina* and proposed the degenerate plate form as *S. stearnsii* var. *inerme*, a view with which Nilsson-Cantell (1928, 1934) agreed. Annandale (1916b) found two Japanese specimens referable to var. *robusta*, and a number of indeterminate forms between var. *robusta* and var. *gemina*, and suggested that, as there was no evidence for Japanese and Malayan races, the two varieties should be united under *S. stearnsii*.

The specimens listed here represent the first records of *S. stearnsii* from eastern Australian waters. The specimens showed conchological characters which have been ascribed to the degenerate plate forms *S. stearnsii* var. *gemina* and *S. inerme* (tergum incompletely calcified in the form of an inverted V, scutum and upper latus reduced in size, peduncular scales smaller, arranged in more numerous rows). Soft-parts morphology and the structure of the dwarf males, however, agreed with descriptions of the more perfectly calcified form *S. stearnsii*, thus supporting the inclusion of *S. inerme* and *S. stearnsii* var. *gemina* in synonymy with the typical form.

MEROSCALPELLINAE Zevina, 1978  
*Alcockianum* Zevina 1978

*Alcockianum alcockianum* (Annandale, 1905)  
(Fig. 3)

*Scalpellum alcockianum* Annandale, 1905: 82; 1906a: 392; 1906b: 138; 1907: pl. 1, fig. 2, pl. 2, figs 2-2b; 1913: 228, 229; 1916a: 129, pl 6 fig. 5.  
*Scalpellum (Scalpellum) alcockianum*: Calman, 1918:

115; Nilsson-Cantell, 1928: 6, fig. 3; 1931: 2; 1938: 7.

*Arcoscalpellum alcockianum*: Newman & Ross, 1971: 60; Lakshmana Rao & Newman, 1972: 70.

*Alcockianum alcockianum*: Zevina, 1978b: 1345; 1981a: 149, fig. 106.

TYPE LOCALITY

S of Ceylon (5°48'15"N, 80°56'E); 'Investigator' station 277; 1750-1609m.

DISTRIBUTION

Indian Ocean, Malay Arch., Indonesia, between Java and Australia (10°45'S, 120°50'E), between southeastern Australia and New Zealand (37°00'S, 165°00'E), New Zealand (46°16'S, 173°22'E), mid-Pacific Ocean (18°31'N, 179°36'W). Depth range 945-1800m. Now also recorded from north-eastern and central eastern Australian waters (945-1950m).

MATERIAL EXAMINED

W\*13256 (16°54'S, 147°14'E), 1473-1590m, 3 specs; P35286 E of Orient Pt, (34°56'-54'S, 151°15'-17'E), 1098-1134m, 3 specs; P35287 E of Shoalhaven Heads, (34°53-50'S, 151°14'-15'E), 945-1017m, 1 spec.; P35294 E of Long Reef Pt, (33°43'-40'S, 152°03'-05'E), 1026-1053m, 3 specs.

SUPPLEMENTARY DESCRIPTION

Large individuals hermaphrodite. Capitulum oval, inflated in upper half, especially between tergum and neighbouring valves. Fourteen capitular plates, concealed by and embedded in thick, opaque membrane, externally velvety; some capitular plates imperfectly calcified, widely separated, paired plates relatively small. Peduncle variable in length, depending on degree of contraction, calcareous scales transversely elongated, arranged in alternating rows. Measurements of the 10 specimens: CH 3.15- 6.60 (mean 5.28), CW 2.47-5.81 (mean 4.31), PL 2.41-8.65 (mean 4.82), PW 1.14-2.90 (mean 2.36).

Cirrus I setose, well separated from cirrus II, anterior ramus shorter than posterior ramus, proximal segments of anterior ramus protuberant posteriorly, inner surfaces of segments of both

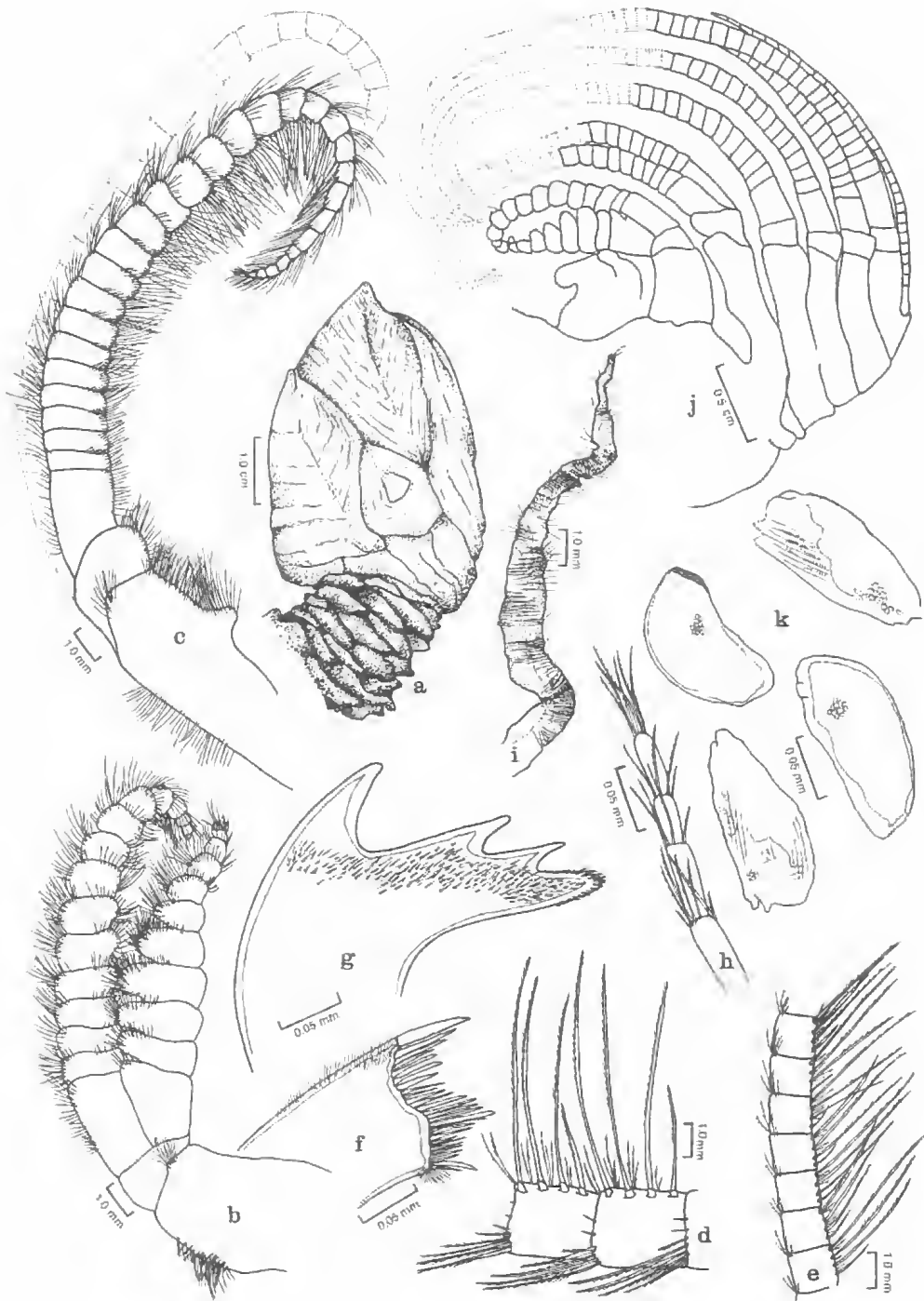


FIG. 3. *Alcockianum alcockianum* (Annandale, 1905). a, lateral view. b, cirrus I. c, cirrus II. d, distal segments, posterior ramus, cirrus II. e, intermediate segments, anterior ramus, cirrus V. f, maxillule. g, mandible. h, distal tip of caudal appendage. i, penis. j, lateral view of prosoma. k, complementary males.

TABLE 2. Measurements and cirral formulae of *Alcockianum alcockianum* (Annandale, 1905)

CH	CW	PL	PW		CI	CII	CIII	CIV	CV	CVI	Ca
3.55	4.10	2.55	2.12	(R)	$\frac{11}{15}$	$\frac{26}{29}$	$\frac{36}{36}$	$\frac{40}{38}$	$\frac{39}{40}$	$\frac{42}{40}$	28
4.84	3.26	2.41	1.80	(R)	$\frac{11}{16}$	$\frac{28}{31}$	$\frac{36}{36}$	$\frac{41}{41}$	$\frac{45}{44}$	$\frac{42}{39}$	29
5.79	4.10	2.55	2.12	(R)	$\frac{9}{16}$	$\frac{29}{27}$	$\frac{24}{37}$	$\frac{27}{36}$	$\frac{42}{44}$	$\frac{41}{42}$	27

rami extremely setose. Cirrus II long, rami subequal, anterior ramus more densely setose than posterior ramus, setae setulate, inner surfaces of segments of both rami densely setose. Cirri III to VI very long, cirri increasing in length towards posterior, rami subequal, segments elongate bearing three to five pairs long, setulate setae on anterior faces, bunch of long finely setulate setae at postero-distal corner of proximal segments of cirri III to V. Chaetotaxy ctenopod. Cirral formulae, see Table 2.

Maxillule with sinuous cutting edge bearing numerous paired setae (30-38 pairs), stout spine at upper angle. Mandible with three main teeth, first large, acute, widely separated from rest, lower angle pectinate. Labrum prominent, bullate. Caudal appendages multi-articulate (22-30 segments), one-third to one-half length of cirrus VI, distal borders of segments with eirelets of setae bearing fine setules, terminal segment with dense tuft of long setae with fine setules. Penis one-quarter length of cirrus VI, slender, minutely annulated, tapering distally, sparsely setose, setae long, plumose. Complementary males (3-4) at occludent margins of both scuta of hermaphrodite, located just above adductor muscle, in shallow pocket formed by fold in scutal membrane; sac-like, ovoid, calcareous plates and cirri absent, orifice slit-like, lateral; externally with elongated spicules arranged in transverse rows.

#### REMARKS

Material collected by *Cidaris* I is the first record of *A. alcockianum* within Australian waters (Jones et al., 1990). Additional material examined in the course of this study has extended the range of the species from northeastern to central eastern Australia. The specimens agreed in general with published descriptions for this species. Some variation in the form of the tergum has been described - for example, the scutal margin of the tergum may be less hollowed out (Annandale, 1906a; Nilsson-Cantell, 1928) or more hollowed out (Annandale, 1916a; Lakshmana Rao & Newman, 1972). The Australian series (n = 10) demonstrated ontogenetic changes of this plate, which is less hollowed out in smaller specimens

(e.g. CH 3.55) but more hollowed out as capitular size increases (e.g. CH 6.60).

Nilsson-Cantell (1928) described a female specimen of *A. alcockianum* from Mozambique Channel at a depth of 1647m. All other descriptions of this species are based on hermaphrodites, including the Australian series.

#### *Alcockianum persona* (Annandale, 1916) (Figs 4.5)

*Scalpellum persona* Annandale, 1916b: 295, pl. 4, fig. 3, pl. 5, figs 7-8, pl. 6, figs 3-5; Calman, 1918: 120.

Nilsson-Cantell, 1934: 44, pl. 5, fig. 2.

*Alcockianum persona*: Zevina, 1978b: 1345; 1981a: 150, fig. 107.

*Graviscalpellum persona*: Foster, 1980: 527, fig. 1c, 2.

#### TYPE LOCALITY

Timor Sea (10°22'30"S, 120°7'30"E); 109-366m; bottom temp 13.1°C.

#### DISTRIBUTION

Indonesian seas, also New Zealand. Depth range 109-915m. Now also recorded from eastern Australia (550m).

#### MATERIAL EXAMINED

W11327, E Bunker Gp (23°15'S, 153°07'E). 550 m, 7 specs.

#### SUPPLEMENTARY DESCRIPTION

Large individuals hermaphrodite. Capitulum ovoid, inflated. Fourteen capitular plates embedded and mostly concealed by opaque, thick membrane, externally finely hirsute; umbos apical, apices projecting through membrane (especially carinolatera); some capitular plates imperfectly calcified (e.g. terga), all plates except scuta relatively small, especially inframedian latus. Peduncle as long as or longer than capitulum, narrowing towards capitular junction, large calcareous scales transversely elongated, arranged in alternating rows. Measurements of the 7 specimens: CH 1.55-4.05 (mean 3.20), CW 1.02-2.79 (mean 2.07), PL 1.62-5.33 (mean 3.40), PW 0.63-1.86 (mean 2.31).

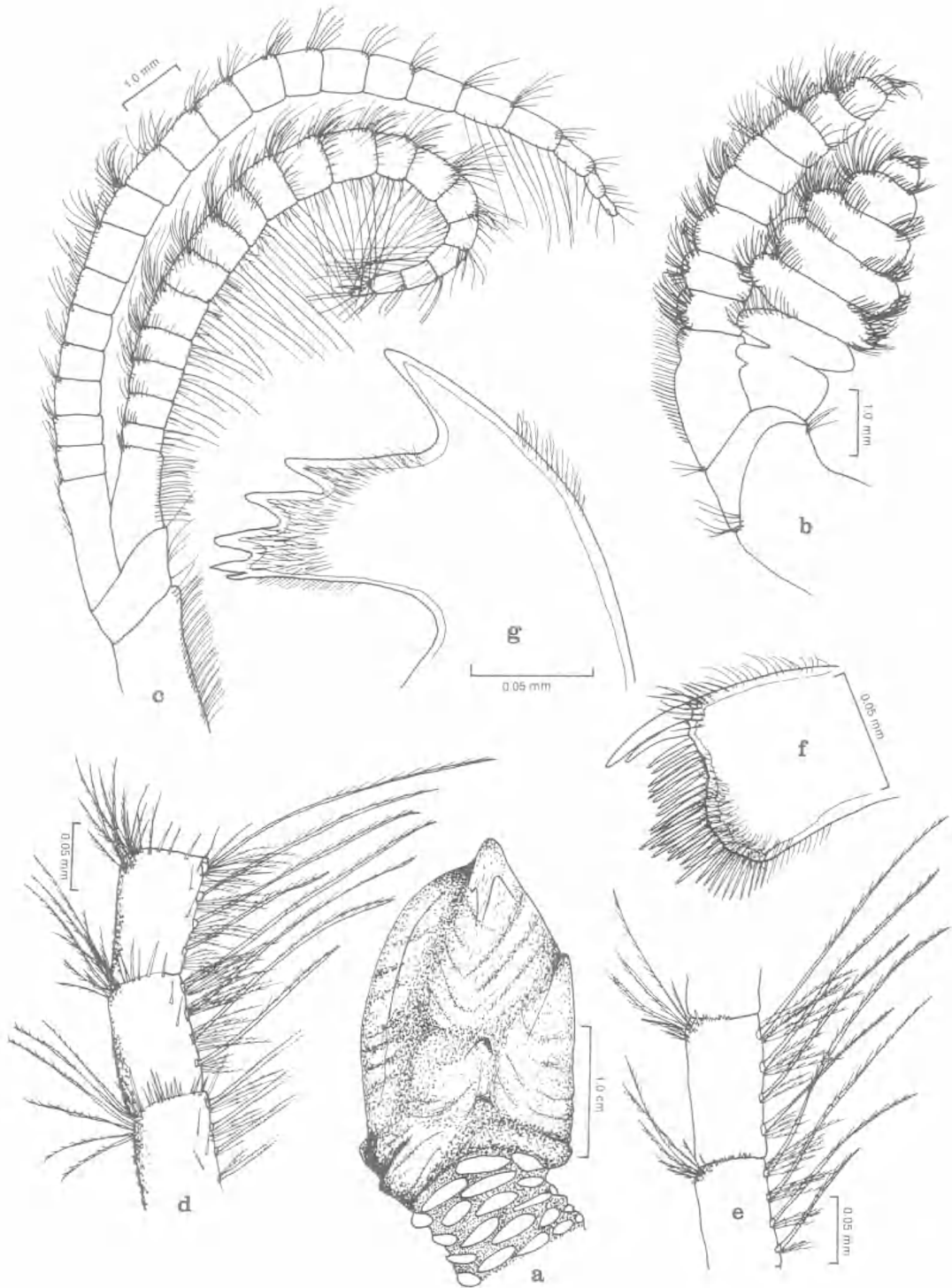


FIG. 4. *Alcockianum persona* (Annandale, 1916). a, lateral view. b, cirrus I. c, cirrus II. d, intermediate segments, anterior ramus, cirrus III. e, intermediate segments, anterior ramus, cirrus V. f, maxillule. g, mandible.



Cirrus I setose, set higher than and slightly separate from cirri II to VI, anterior ramus shorter than posterior ramus, proximal and intermediate

segments of anterior ramus protuberant especially towards posterior, inner surfaces of segments of both rami with dense, setulate setae. Cirrus II long,

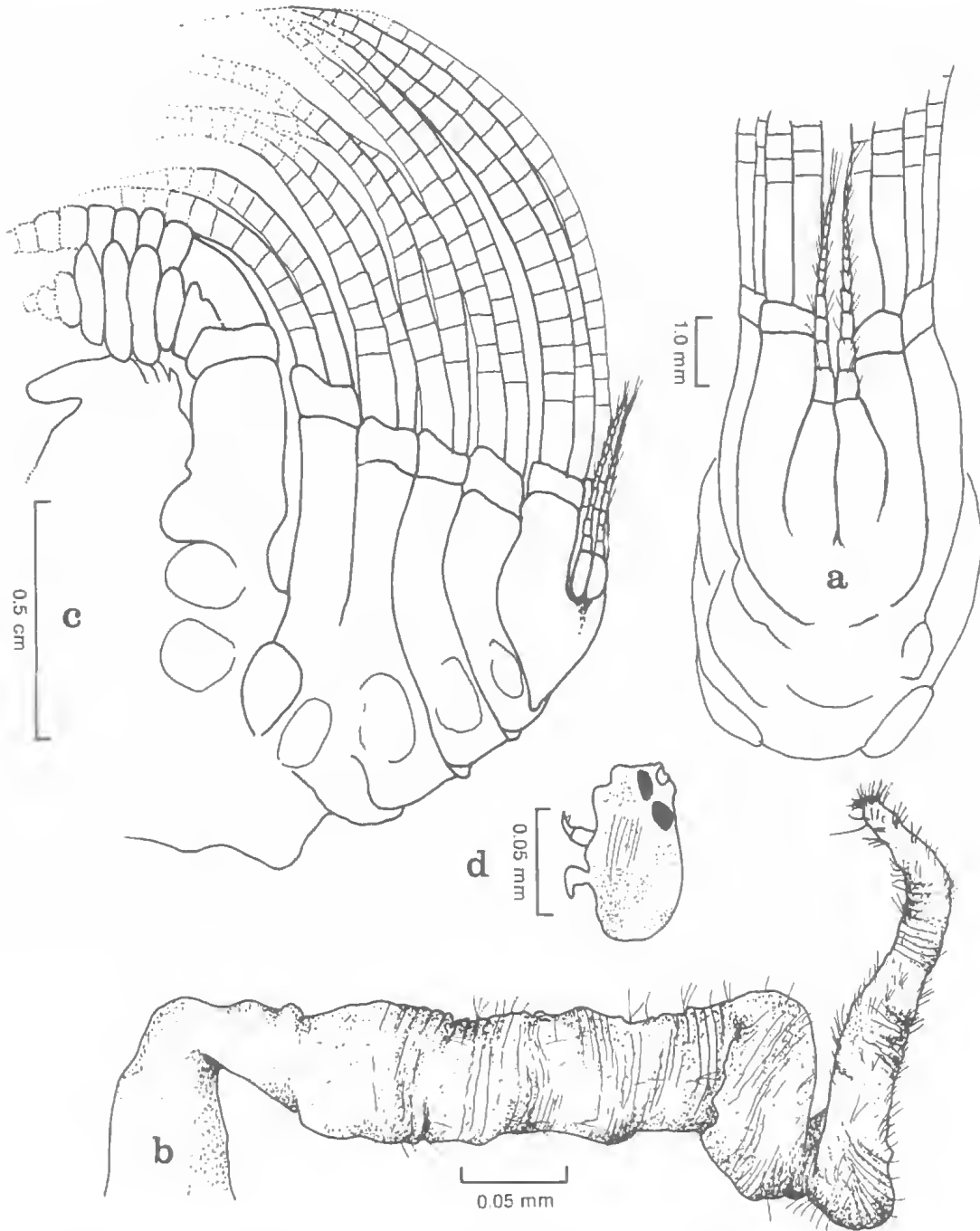


FIG. 5. *Alcockianum persona* (Annandale, 1916). a, posterior view, caudal appendages and pedicels of posterior cirri. b, penis. c, lateral view of prosona. d, complementary male.

TABLE 3. Measurements and cirral formula of *Alcockianum persona* (Annandale, 1916).

CH	CW	PL	PW		CI	CII	CIII	CIV	CV	CVI	Ca
4.05	2.79	4.40	1.86	(R)	$\frac{14}{18}$	$\frac{26}{28}$	$\frac{36}{38}$	$\frac{17+}{17+}$	$\frac{15+}{14+}$	$\frac{15+}{17+}$	13

rami subequal, anterior ramus more setose than posterior ramus, setae setulate. Cirri III to VI very long, cirri increasing in length towards posterior, rami subequal, segments square to elongate, bearing three to six pairs long setulate setae on anterior faces, bunch of long, finely setulate setae at postero-distal corner of proximal segments of cirri III to VI. Chaetotaxy ctenopod. Cirral formula, see Table 3.

Maxilla with characteristic development of olfactory organ in the form of a blunt process. Maxillule with slightly sinuous cutting edge bearing numerous paired setae (25-30 pairs), two stout spines at upper angle. Mandible with 5 teeth, first acute, large, widely separated from remainder, lower angle molariform. Labrum extremely bulate, prominent. Caudal appendages multiarticulate (13-16 segments), twice length of pedicel of cirrus VI, segments with circlets of setulate setae, distal segment with dense tuft of setae, proximal segment expanded. Penis relatively long, one-third to one-half length of cirrus VI, annulated, tapering distally, setose towards apex, apex blunt with circlet of fine short setae. Complementary males at occludent margin of both scuta of hermaphrodite, located just above adductor muscle in deep pit in scutal membrane; ovoid, sac-like, four reduced calcareous plates around subterminal orifice, externally with small spicules, two prehensile antennae on ventral margin.

#### REMARKS

*A. persona* is similar to *A. alcockianum* but the two species are easily distinguished by characters of the tergum, carinolatera, caudal appendages and mandible.

The specimens of *A. persona* described above are the first collected from Australian seas. These specimens agree in general with published descriptions of conchology for *A. persona* (Annandale, 1916). However, the form of the mandible of Australian specimens differs from that previously described in that they exhibit five definite teeth, rather than four as figured by Annandale (1916b) for Indonesian material and Foster (1980) for New Zealand specimens. Australian specimens also do not exhibit a notch on the maxillule, whereas New Zealand specimens show a slight notch (Foster, 1980) and Indonesian material a broad shallow notch (Annandale, 1916b). The characteristic blunt

conical olfactory lobe of the maxilla is, however, exhibited by Indonesian, Australian and New Zealand specimens.

#### Annandaleum Newman & Ross, 1971

##### *Annandaleum lambda* (Annandale, 1910) (Fig. 6)

*Scalpellum lambda* Annandale, 1910: 115; 1913: 234; 1916a: 130, pl. 7, figs 6, 6a, pl. 8, figs 12-15.

*Scalpellum longius* Annandale, 1913: 234; 1916a: 130, pl. 7, figs 5, 5a; Stubbings, 1936: 27, fig. 11.

*Annandaleum lambda*: Newman & Ross, 1971: 122; Zevina, 1981a: 168, fig. 120.

#### TYPE LOCALITY

Eastern Indian Ocean (13°54'15"N, 94°02'15"E); 'Investigator' station 372; 1176m.

#### DISTRIBUTION

Indian Ocean. Depth range 237-1960m. Now also recorded from northeastern Australia (956-969m).

#### MATERIAL EXAMINED

W\*13238 (18°08'S, 147°36'E), 956-969m, 1 spec.

#### SUPPLEMENTARY DESCRIPTION

Large individuals female. Capitulum irregularly ovate, laterally compressed. Fourteen capitular plates, smooth, thin, imperfectly calcified, separate, eight in shape of Greek lambda ( $\lambda$ ). Inframedian latus large, vase-shaped. Peduncle shorter than capitulum, numerous calcareous scales present, narrow, transversely elongated, arranged in alternating rows. Cirrus I long, placed at a distance from cirrus II, rami very unequal, anterior ramus shorter and broader than posterior ramus; inner surfaces of both rami densely setose. Cirri II to VI very long, cirri increasing in length to posterior, rami subequal, segments elongate, bearing four to six pairs of long setae on anterior faces. Chaetotaxy ctenopod. Cirral formula, see Table 4.

Maxillule with definite notch, cutting edge below notch bearing two to three pairs setae, lower angle spinose, three stout subequal spines at upper angle. Mandible with three main teeth, lower angle pectinate. Labrum bullate. Caudal append-

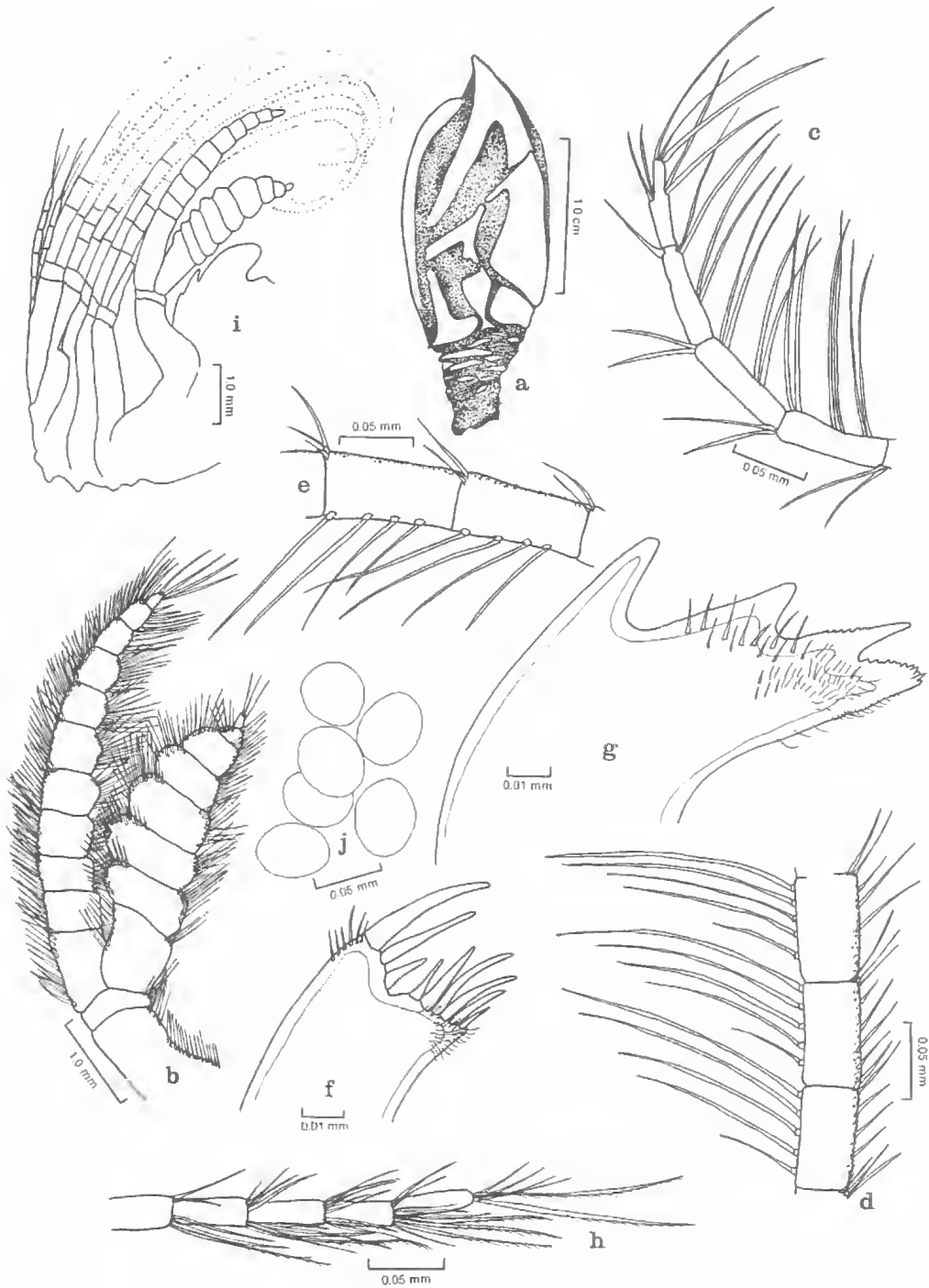


FIG. 6. *Annandaleum lambda* (Annandale, 1910). a, lateral view. b, cirrus I. c, distal segments, posterior ramus, cirrus III. d, intermediate segments, anterior ramus, cirrus III. e, intermediate segments, anterior ramus, cirrus V. f, maxillule. g, mandible. h, distal tip of caudal appendage. i, lateral view of prosoma. j, ova.

TABLE 4. Measurements and cirral formula of *Annandaleum lambda* (Annandale, 1910).

CH	CW	PL	PW		CI	CII	CIII	CIV	CV	CVI	Ca
1.68	0.94	0.60	0.61	(R)	$\frac{8}{12}$	$\frac{18}{18}$	$\frac{21}{23}$	$\frac{23}{25}$	$\frac{26}{27}$	$\frac{29}{29}$	8

ages moderately long, one-fifth length of cirrus VI, multi-articulate (6-8 segments), long setae with setules at distal tip, Penis absent. Dwarf males unknown. Ova large, ovoid, yolky, lemon yellow in preserved material.

## REMARKS

This species was first described by Annandale (1910) from material collected in the Andaman Sea. Annandale (1913) also described *S. longius* from the Andamans and commented that the species may possibly be '... merely a complete form of *S. lambda*...', differences being the degree of reduction of the capitular plates, the structure of the carinolatera and the relative lengths of the rami of cirrus I and the number of segments in the caudal appendages. Stubbings (1936) examined *S. longius* from Zanzibar and found the specimens agreed with the type description and '... showed no tendency to vary towards *S. lambda*'.

The sole Australian specimen described here shows characters attributable to both *S. lambda* and *S. longius*. The form of the carinolatera and the degree of reduction of the capitular plates agree in general with conchology described for *S. lambda* but differ in the following details: the apex of the carina almost touches the carinal margins of the terga; the tergal branch of the scutum is much shorter than that illustrated by Annandale (1910) but not as short as shown by Zevina (1981a); scutum, rostrilatera and carinolatera are more similar to the form illustrated by Annandale (1910) than that of Zevina (1981a); scutal arm of upper latus exhibits a bifid tip. Mandibles and maxillules of the Australian material resemble the forms figured by Stubbings (1936) for *S. longius*. In addition, both mandibles of the Australian specimen have three small, well-spaced spines on the upper margin of the third tooth and on the upper margin of the lower angle, which have not been figured previously for either *S. lambda* or *S. longius*. Rami of cirrus I in the Australian specimen are very unequal in length. These structures have been described as equal (Annandale, 1913) or subequal (Stubbings, 1936) in *S. longius* and unequal in *S. lambda* (Annandale, 1910). Caudal appendages of the Australian specimen are eight segmented. This structure appears to be similar in *S. lambda* (8 segments; Annandale,

1910) and *S. longius* (6 segments; Annandale, 1913; 8 segments; Stubbings, 1936).

The similarity of conchological and arthropodal characters support the conclusion that *S. longius* is a junior subjective synonym of *S. lambda*, as originally suggested by Annandale (1913) and later formalized - although not discussed - by Newman & Ross (1971) and Zevina (1981a). The Australian specimen collected by Cidaris I extends the geographical range of this species from the Indian Ocean to the waters of northeastern Queensland (Jones et al., 1990).

ARCOSCALPELLINAE Zevina, 1978  
Verum Zevina, 1978

*Verum australicum* (Hoek, 1883)  
(Figs 7,8)

*Scalpellum australicum* Hoek, 1883: 118, pl. 5, fig. 11;  
Weltner, 1922: 63.  
*Verum australicum*: Zevina, 1981a: 223, Fig. 160.

## TYPE LOCALITY

Between New Guinea and Australia (12°08'S, 145°10'E); 'Challenger' station 184; 2561m; bottom temp. 1.8°C; substrate grey ooze.

## DISTRIBUTION

Zanzibar; between Australia and New Guinea. Depth range 463-2561m. Now also recorded from northeastern Australia (1187-1590m).

## MATERIAL EXAMINED

W\*13239 (16°54'S, 137°14'E), 1473-1590m, 1 spec.;  
W\*13240 (17°19'S, 147°11'E), 1402-1406m, 10 specs;  
W\*13241 (17°20'S, 147°48'E), 1187-1200m, 1 spec.

## SUPPLEMENTARY DESCRIPTION

Large individuals female. Capitulum oval, elongate, laterally compressed. Thirteen capitular plates, distinctly furrowed, closely approximate. Inframedian latus elongate, vase-shaped. Peduncle short, one-third to one-sixth capitular height, calcareous scales distinct, larger towards capitulum, arranged in five to six alternating rows. Measurements of the 12 specimens: CH 1.24-2.40 (mean 2.00), CW 0.58-1.35 (mean 1.06), PL 0.20-0.87 (mean 0.56), PW 0.09-0.68 (mean 0.52).

Cirrus I set apart from cirrus II, rami unequal,

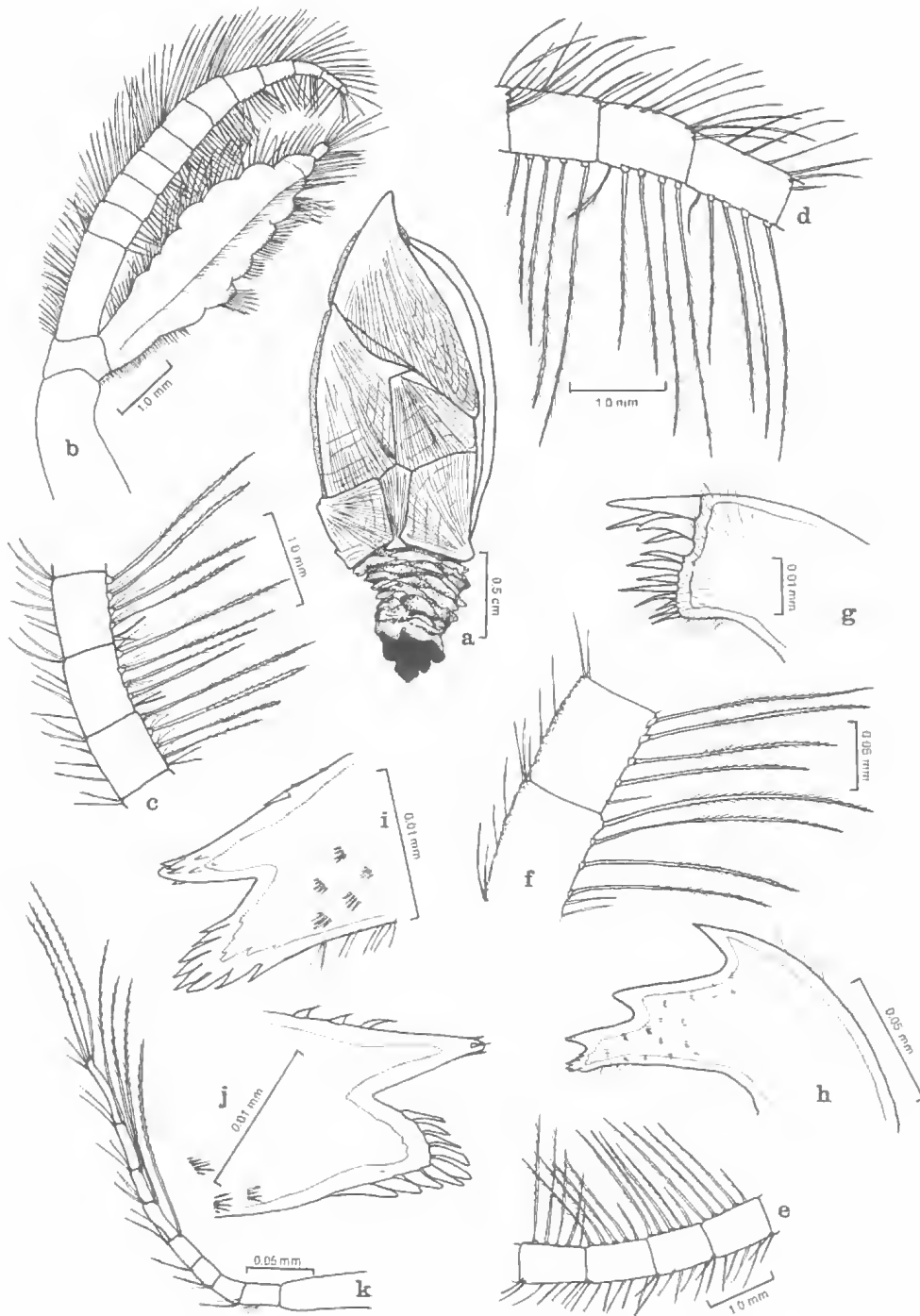


FIG. 7. *Verum australicum* (Hoek, 1883). a, lateral view. b, cirrus I. c, intermediate segments, anterior ramus, cirrus II. d, distal segments, posterior ramus, cirrus III. e, intermediate segments, posterior ramus, cirrus V. f, proximal segments, posterior ramus, cirrus V. g, maxillule. h, mandible. i, j, lower angle of mandible. k, distal tip of caudal appendage.

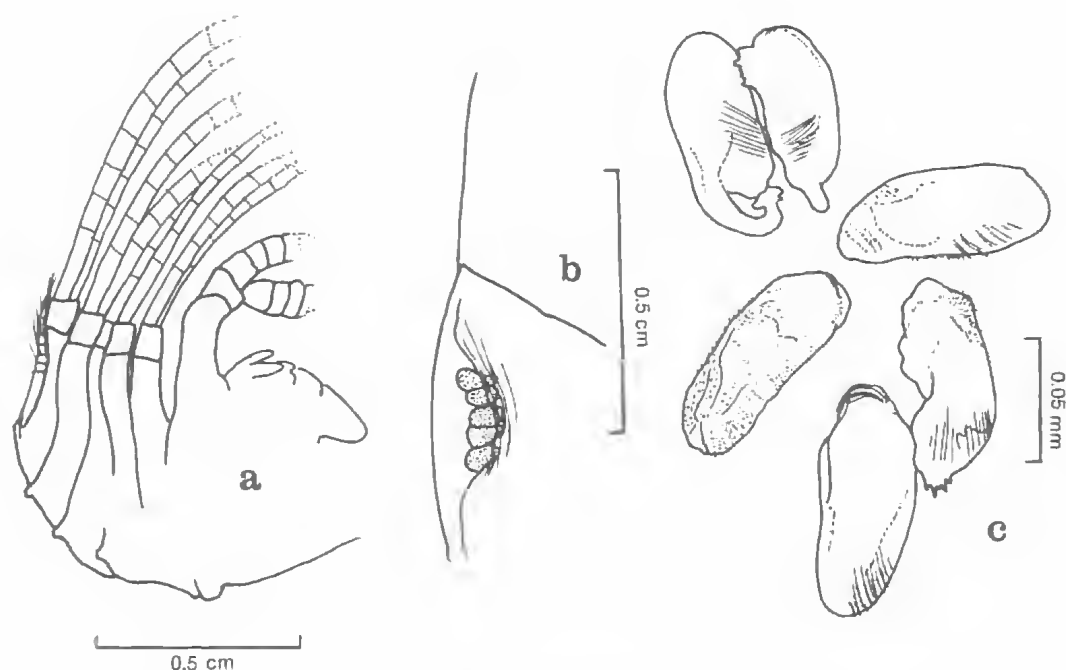


FIG. 8. *Verum australicum* (Hoek, 1883). a, lateral view of prosoma. b, dwarf males in scutal pocket. c, dwarf males.

anterior ramus shorter and much broader than posterior ramus, both rami densely setose. Cirri II to VI very long, cirri increasing in length to posterior, rami subequal, segments elongate, bearing four to five pairs of long setulate setae on anterior faces. Chaetotaxy ctenopod. Cirral formulae, see Table 5.

Maxillule with slight notch, four to five spines on cutting edge below notch, three stout subequal spines at upper angle, lower angle spinose. Mandible with three main teeth, lower angle pectinate, upper margin of third tooth with several small spines. Labrum extremely bullate, teeth absent. Caudal appendages short, marginally longer than pedicel of cirrus VI, multiarticulate (nine segments), long setae bearing fine setules distally. Penis absent. Dwarf males in pocket at occludent margin, on inner surface of and towards apex of right and left scuta of female, three to six males

per pocket; males sac-like, ovoid, externally with chitinous spines, calcareous plates absent.

#### REMARKS

The material collected by Cidaris I extends the range of *V. australicum* into the waters of north-eastern Australia (Jones et al., 1990). The conchology of the specimens agrees in general with the original description of Hoek (1883). However, Hoek stated (p. 118) that the 13 plates were 'closely locked together' and that there were 'no distinct interspaces between the different valves'. In the ontogenetic series of the Australian material an interspace develops between the carinal margin of the tergum and the upper portion of the carina in larger specimens (CH 2.20+). Hoek's type description was based on a smaller specimen (CH 1.25).

Hoek (1883) did not describe the internal structure of *V. australicum* and did not observe dwarf

TABLE 5. Measurements and cirral formulae of *Verum australicum* (Hoek, 1883).

CH	CW	PL	PW		CI	CII	CIII	CIV	CV	CVI	Ca
2.26	1.20	0.74	0.68	(R)	$\frac{8}{12}$	$\frac{17}{18}$	$\frac{20}{21}$	$\frac{26}{28}$	$\frac{25}{26}$	$\frac{26}{26}$	9
2.40	1.35	0.87	0.63	(R)	$\frac{9}{12}$	$\frac{18}{20}$	$\frac{23}{25}$	$\frac{27}{30}$	$\frac{29}{29}$	$\frac{31}{34}$	9

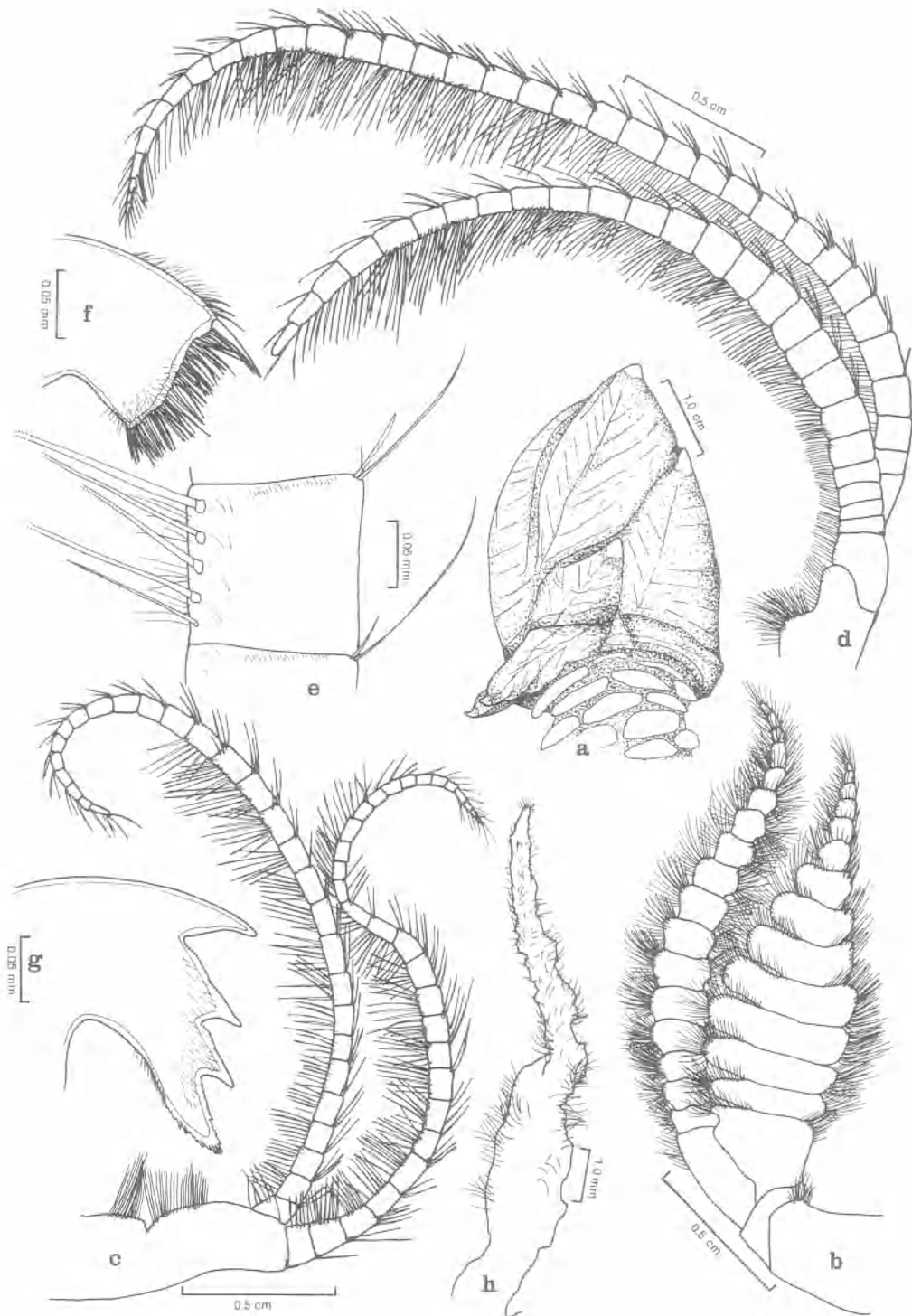


FIG. 9. *Anguloscalpellum pedunculatum* (Hoek, 1883), a, lateral view. b, cirrus I. c, cirrus II. d, cirrus III. e, intermediate segments, posterior ramus, cirrus IV. f, maxillule. g, mandible. h, penis.

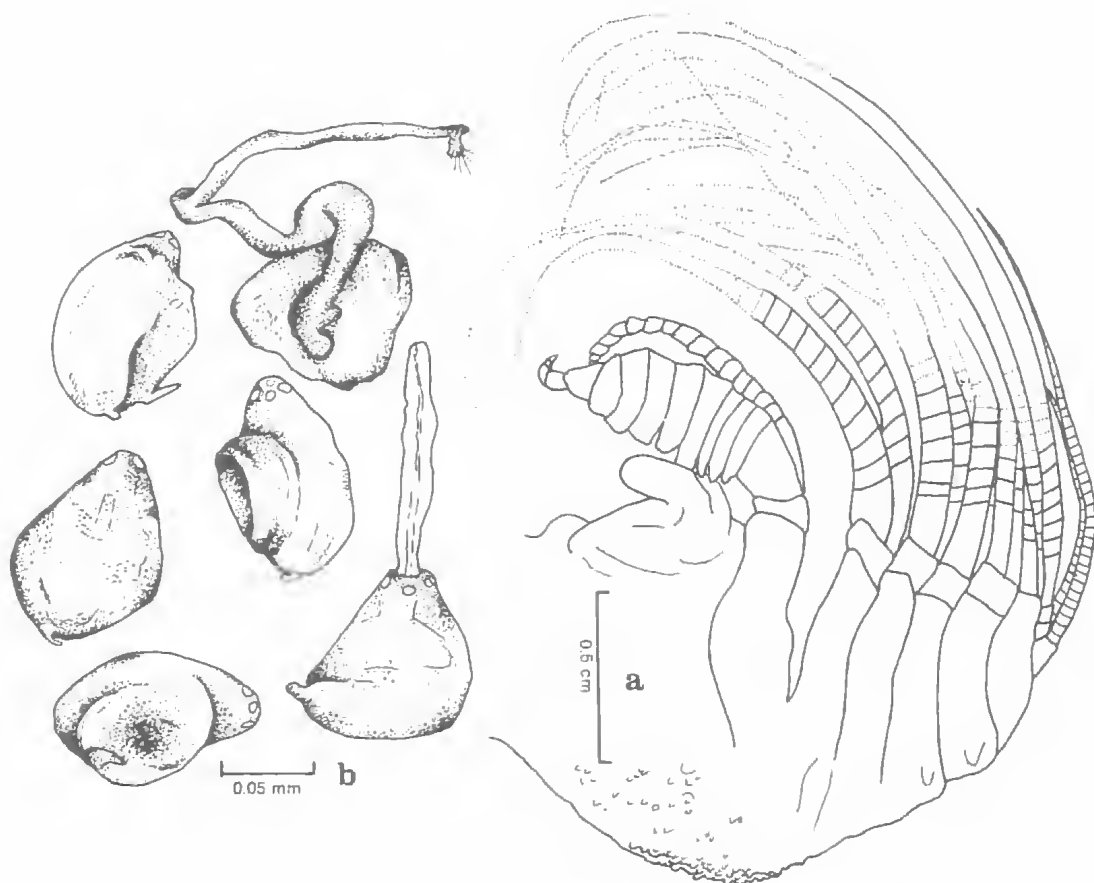


FIG. 10. *Anguloscalpellum pedunculatum* (Hock, 1883). a, lateral view of prosoma. b, complementary males.

males. Details of cirri, mouthparts, caudal appendages and the penis, and observations of complementary males of the species are described here for the first time.

#### ***Anguloscalpellum* Zevina, 1978**

#### ***Anguloscalpellum pedunculatum* (Hock, 1883) (Figs 9,10)**

*Scalpellum pedunculatum* Hock, 1883: 99, pl. 6, figs 1-2.

*Arcoscalpellum pedunculatum*: Foster, 1978: 53, Pl. 7A, fig. 31.

*Graviscalpellum pedunculatum*: Foster, 1980: 527, fig 3H.

*Anguloscalpellum pedunculatum*: Zevina, 1981a: 266, fig. 200.

#### **TYPE LOCALITY**

Pacific Ocean, near New Zealand (39°32'S, 171°48'E); 'Challenger' station 167; 274m; substrate grey ooze.

#### **DISTRIBUTION**

Western Pacific Ocean, New Zealand, Kermadecs, Norfolk I., central eastern Australia. Depth range 202-600m. Now also known from northeastern Australia (300-540m).

#### **MATERIAL EXAMINED**

W11222, E of Murray I. (09°51'S, 144°26'E), 480m, 2 specs; W\*13242 (17°35'S, 146°53'E), 458-500m, 1 spec.; W10193, SE of Saumarez Reef (22°36'S, 154°14'E), 522m, 13 specs; W10192, 50 km NE Capricorn Gp (23°00'S, 153°00S, 153°18'E), 387m, 4 specs; W10191, 110 km E of Capricorn Gp (23°11'S, 153°00'E), 420m, 8 specs; W11324, E of Capricorn Gp (23°21'S, 153°23'E), 410m, 2 specs; W10190, 100 km



TABLE 6. Measurements and cirral formulae of *Anguloscalpellum pedunculatum* (Hoek, 1883).

CH	CW	PL	PW		CI	CII	CIII	CIV	CV	CVI	Ca
4.37	3.19	5.77	1.96	(R)	$\frac{15}{18}$	$\frac{31}{32}$	$\frac{31}{33}$	$\frac{24}{34}$	$\frac{35}{36}$	$\frac{35}{35}$	39
3.33	2.33	4.25	1.90	(R)	$\frac{13}{17}$	$\frac{26}{27}$	$\frac{31}{31}$	$\frac{31}{35}$	$\frac{34}{33}$	$\frac{34}{35}$	37

E of Capricorn Gp (23°30'S, 153°04'E), 540m, 29 specs; W11303 (part), E of Bunker Gp (23°54'S, 153°01'E), 465m, 2 specs; W11468, E of Bunker Gp (23°59'S, 152°59'E), 380m, 12 specs; W14334, off Morton I. (27°12'S, 153°52'E), 3 specs; W15351, off Morton I. (27°13'S, 153°52'E), 590m, 1 spec.; P35288 E of Gold Coast (28°02'-27°59'S, 153°59'E), 540m, 20 specs; P35290 E of Gold Coast (28°02'-27°59'S, 153°59'E), 300m, 26 specs; P35289 E of Gold Coast (28°02'-05'S, 153°57'E), 360m, 1 spec.; P35208, E of Crowdy Head (32°06'-03'S, 153°04'-05'E), 360m, 1 spec.

#### SUPPLEMENTARY DESCRIPTION

Large individuals hermaphrodite. Capitulum subtriangular, inflated towards peduncle. Fourteen capitular plates, concealed by chitinous, hirsute membrane, apices projecting through membrane, plates of lower whorl short, small. Carinolatus elongated, subtriangular, extending outwards from capitulum laterally in larger specimens. Peduncle longer than capitulum, calcareous scales present, transversely elongated, arranged in alternating rows, covered by chitinous, hirsute membrane. Measurements of the 49 specimens: CH 2.68-4.68 (mean 4.05), CW 1.91-3.39 (mean 2.91), PL 4.60-12.97 (mean 8.19), PW 1.28-2.98 (mean 1.96).

Cirrus I slightly separated from cirrus II, rami unequal, proximal segments of anterior ramus wider than those of posterior ramus, strongly protuberant posteriorly, distal segments antenniform, segments of posterior ramus not protuberant. Cirri II to VI long, cirri increasing in length towards posterior, rami subequal, segments square, bearing four to seven pairs of long setae on anterior margins. Chaetotaxy ctenopod. Cirral formulae, see Table 6.

Maxillule with large spine at upper angle, cutting edge slightly sinuous, bearing numerous pairs of stout setae. Mandible with three large teeth, lower angle molariform, pectinated. Labrum extremely ballate, cutting edge straight with minute teeth. Caudal appendages multiaarticulate, long (6-37 segments), half to two-thirds length of cirrus VI. Penis long, slender, tapering distally, sparsely setose, circlet of short dense setae at distal tip. Complementary males globulo-ovoid, orifice ter-

terminal, surrounded by four minute rudimentary plates, externally with chitinous spines in regular pattern, two prehensile antennae on ventral margin, extensile penis present; in shallow scutal pocket of hermaphrodite, three to four males per pocket, membrane of pocket with chitinous spines in regular pattern, membrane closely apposed to males.

#### REMARKS

Foster (1978, 1980) described material from New Zealand waters, Norfolk Island and the Kermadecs and mentioned that the species was also known to occur in the waters of eastern Australia (29°S), at a depth of 500-600m. *Cidaris* I specimens of *A. pedunculatum* extended the known geographic range of the species northwards into the waters of north-eastern Queensland (17°S) (Jones et al., 1990) and material examined in the present study further extends the total range of the species from 32°S to Torres Strait (9°S).

Australian hermaphrodites agree well with published descriptions. The presence of a penis in the complementary male is confirmed and the orifice is terminal, rather than lateral as illustrated by Foster (1978) for New Zealand material. The close proximity of the scutal pocket membrane to the complementary males suggests the possibility of an interlocking function between the chitinous spines of the inner surface of the pocket and the external surface of the males, thus maintaining the males securely in the pouch.

*Amigoscalpellum* Zevina, 1978  
*Amigoscalpellum daschae* Zevina, 1981  
 (Fig. 11)

*Amigoscalpellum daschae* Zevina, 1981a: 290, fig. 219; 1981b: 87, fig. 9.

#### TYPE LOCALITY

SE of Papua New Guinea (11°30.5'S, 152°11.7'E); depth 3080m.

#### DISTRIBUTION

Type locality (3080m) and now also known from north-eastern Australia (1517-1564m).

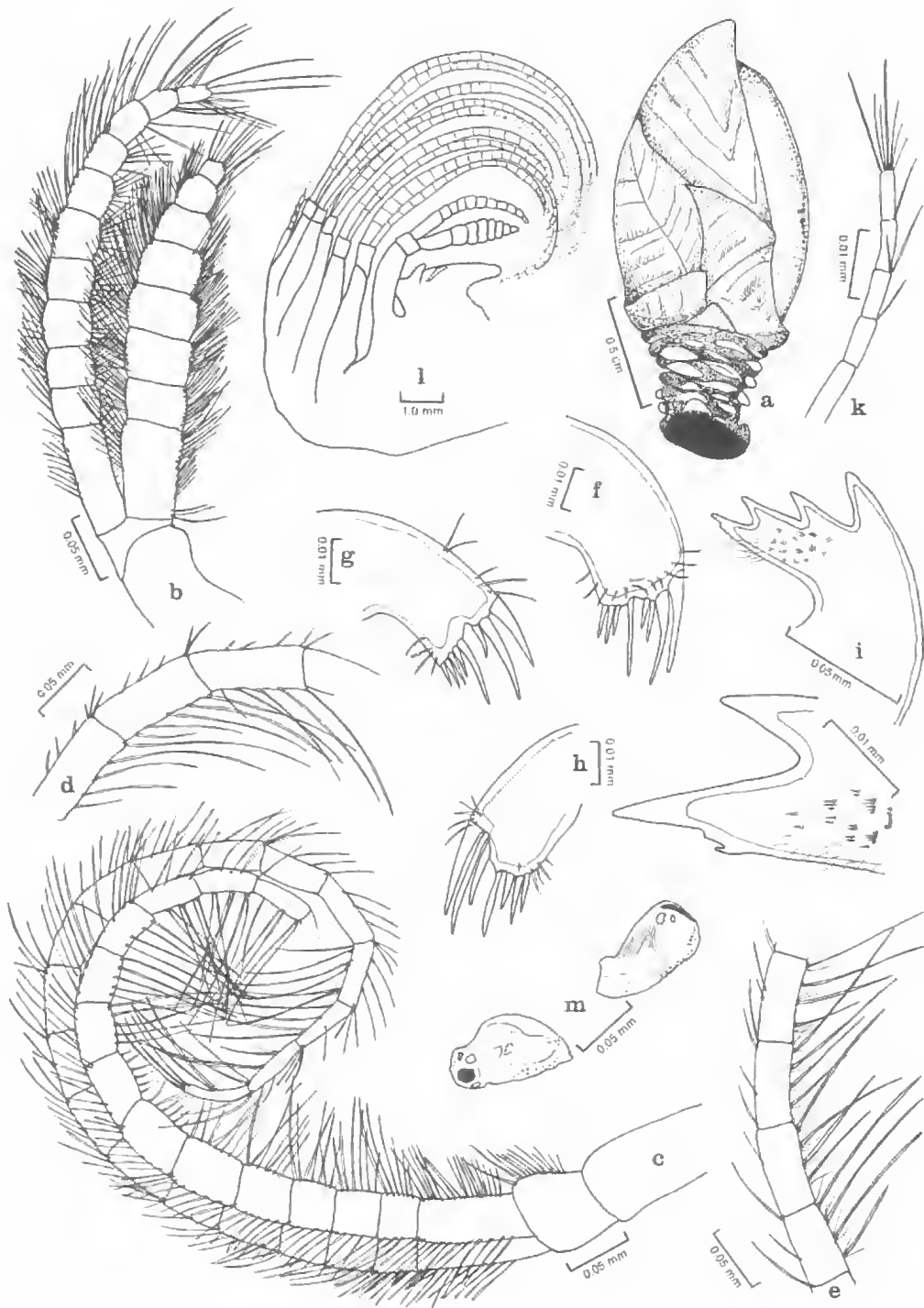


FIG. 11. *Amigdoscalpellum daschae* Zevina, 1981. a, lateral view. b, cirrus I. c, cirrus II. d, distal segments, posterior ramus, cirrus III. e, median segments, posterior ramus, cirrus V. f-h, maxillule. i, mandible. j, lower angle of mandible. k, distal tip of caudal appendage. l, lateral view of prosoma. m, dwarf males.

TABLE 7. Measurements and cirral formulae of *Amigdoscalpellum daschae* Zevina, 1981.

CH	CW	PL	PW		CI	CU	CUI	CIV	CV	CVI	Ca
1.21	0.76	0.53	0.43	(R)	$\frac{7}{8+}$	$\frac{12+}{13+}$	$\frac{11+}{12+}$	$\frac{9+}{10+}$	$\frac{10+}{10+}$	$\frac{2+}{10+}$	5
1.35	0.82	0.63	0.48	(R)	$\frac{8}{11}$	$\frac{15+}{20}$	$\frac{20}{22}$	$\frac{22}{25}$	$\frac{23}{26}$	$\frac{25}{24}$	5

TABLE 8. Measurements and cirral formulae of *Amigdoscalpellum elegans* (Hoek, 1907).

CH	CW	PL	PW		CI	CII	CIII	CIV	CV	CVI	Ca
2.05	0.90	0.46	0.43	(R)	$\frac{9}{12}$	$\frac{19}{21}$	$\frac{26}{26}$	$\frac{27}{28}$	$\frac{28}{28}$	$\frac{29}{32}$	1
1.37	0.65	0.25	0.35	(R)	$\frac{8}{10}$	$\frac{17}{19}$	$\frac{23}{23}$	regenerating			1

## MATERIAL EXAMINED

W\*13244 (16°59'S, 147°11'E), 1545-1564m, 1 spec;  
W\*13243 (17°06'S, 147°12'E), 1517-1539m, 2 specs.

## SUPPLEMENTARY DESCRIPTION

Large individuals female. Capitulum irregularly ovate, carinal margin more strongly curved than occludent margin. Thirteen capitular plates partially covered by thin, finely setose membrane, fine growth lines visible externally on all plates. Peduncle short, cylindrical, calcareous scales well developed, overlapping, arranged in alternate rows, covered with thin, finely setose membrane. Cirrus I much shorter than and set apart from cirri II to VI, anterior ramus shorter than and slightly wider than posterior ramus, both rami setose, especially inner surfaces. Cirri II to VI long, cirri increasing in length towards posterior, rami subequal, segments elongate, bearing four to five pairs long setae on anterior faces. Chactotaxy ctenopod. Cirral formulae, see Table 7.

Maxillule with shallow median notch, two stout subequal setae at upper angle, one long seta and three pairs shorter setae below notch. Mandible with three main teeth, lower angle molariform with one or two small teeth on lower margin. Labrum bullate, cutting edge straight, teeth absent. Caudal appendages multiarticulate (5-6 segments), short, extending just beyond pedicel of cirrus VI, one twelfth length of cirrus VI, long setae bearing setules apically. Penis absent. Dwarf males in single row in shallow pocket at occludent margin, on inner surface of both scuta, towards apices; sac-like, four small rudimentary plates around terminal orifice, externally with small cuticular spines.

## REMARKS

Material collected by Cidaris I extended the distribution of *A. daschae* into the waters of north-eastern Australia (Jones et al., 1990). The form of

the mandible of Australian specimens differs from that figured by Zevina (1981b). The pectination of the molariform lower angle, especially of the lower margin, is absent with only one or two small teeth or residual teeth present on the lower mandibular margin in Australian material.

*Amigdoscalpellum elegans* (Hoek, 1907)  
(Figs 12,13)

*Scalpellum elegans* Hoek, 1907; 107, pl. 8, fig. 9;  
Stubbings, 1936: 24.

*Amigdoscalpellum elegans*: Zevina 1981a: 268, fig. 201.

## TYPE LOCALITY

Sulawesi (5°39'S, 122°12'E), 'Siboga' Station 208, 1886m, substrate solid green mud.

## DISTRIBUTION

Indo-west Pacific - South Arabian coast, Sulawesi Depth range 687-1886m. Now also known from northeastern Australia (687- 1228m).

## MATERIAL EXAMINED

W\*13245 (17°20'S, 147°48'E), 1187-1200m, 3 specs;  
W\*13246 (18°04'S, 147°19'E), 687-704m, 1 spec.;  
W\*13247 (17°45'S, 147°48'E), 1223-1228m, 2 specs;  
W\*13248 (18°11'S, 148°22'E), 1109-1110m, 1 spec.

## SUPPLEMENTARY DESCRIPTION

Large individuals female. Capitulum elongate, irregularly ovate, laterally compressed, carinal margin arched, occludent margin almost straight. Thirteen capitular plates, closely approximate, partially covered by thin, finely setose membrane, all plates except carina externally finely striated. Peduncle short, cylindrical, well-developed calcareous scales present, overlapping, arranged in rows, covered with thin, finely setose membrane. Measurements of the seven specimens: CH 0.89-

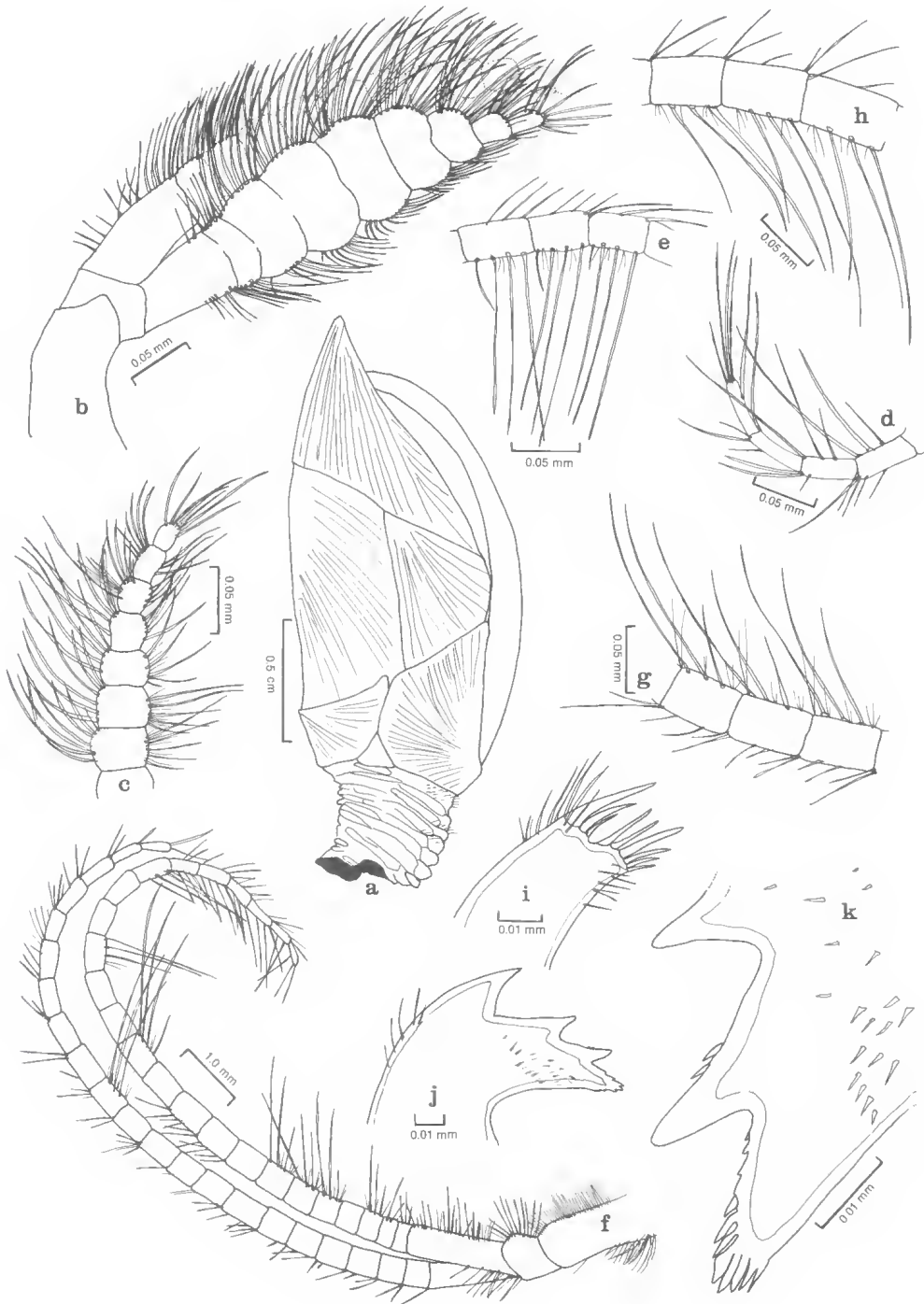


FIG. 12. *Amigoscalpellum elegans* (Hoek, 1907). a, lateral view. b, cirrus I. c, distal segments, posterior ramus, cirrus I. d, distal segments, anterior ramus, cirrus II. e, intermediate segments, posterior ramus, cirrus II. f, cirrus II. g, intermediate segments, anterior ramus, cirrus V. h, intermediate segments, anterior ramus, cirrus VI. i, maxillule. j, mandible. k, lower angle of mandible.

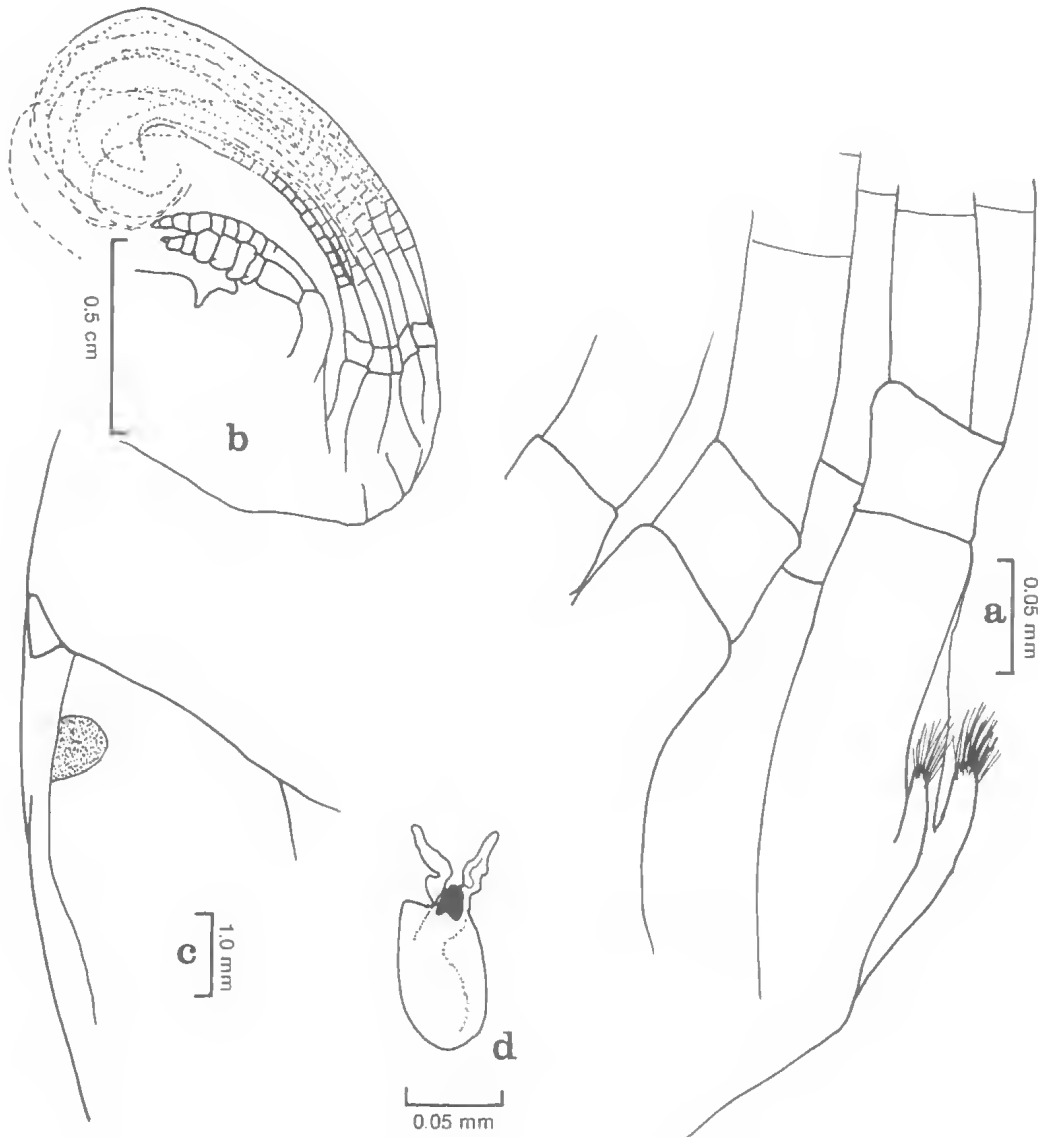


FIG. 13. *Amigdoscappelium elegans* (Hoek, 1907). a, lateral view of prosoma to show caudal appendages. b, lateral view of prosoma. c, dwarf male in scutal pocket. d, dwarf male.

2.05 (mean 1.51); CW 0.39-2.05 (mean 0.69); PL 0.15-0.47 (mean 0.34); PW 0.14-0.48 (mean 0.35).

Cirrus I set above and slightly apart from remaining cirri, rami setose, anterior ramus shorter than posterior ramus, with intermediate segments broad but tending to antenniformy distally. Cirrus II with rami long, subequal, segments becoming elongate distally, anterior ramus more setose than posterior ramus. Cirri III to VI very

long, rami subequal, segments elongate, bearing three to four pairs long setae on anterior margins. Chaetotaxy ctenopod. Cirral formulae, see Table 8.

Maxillule with small notch, definite, one stout spine at upper angle and one pair shorter setae above notch, three pairs of setae on cutting edge below notch, lowest pair longest, three pairs small setae towards lower angle. Mandible with three main teeth, lower angle coarsely pectinate, upper

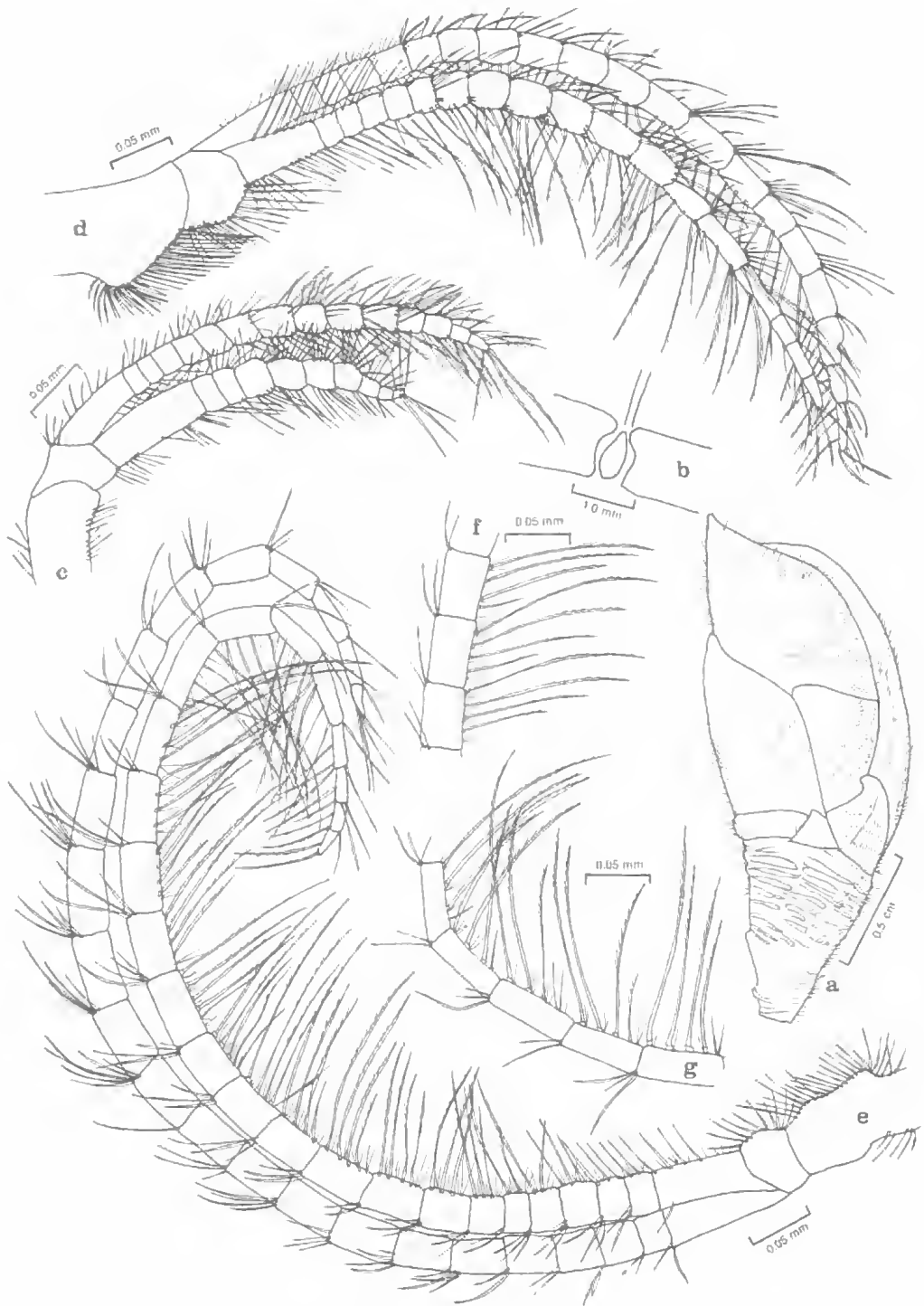


FIG. 14. *Trianguloscalpellum hamulus* (Hoek, 1907). a, lateral view. b, rostrum. c, cirrus I. d, cirrus II. e, cirrus III. f, proximal segments, anterior ramus, cirrus V. g, distal segments, posterior ramus, cirrus VI.

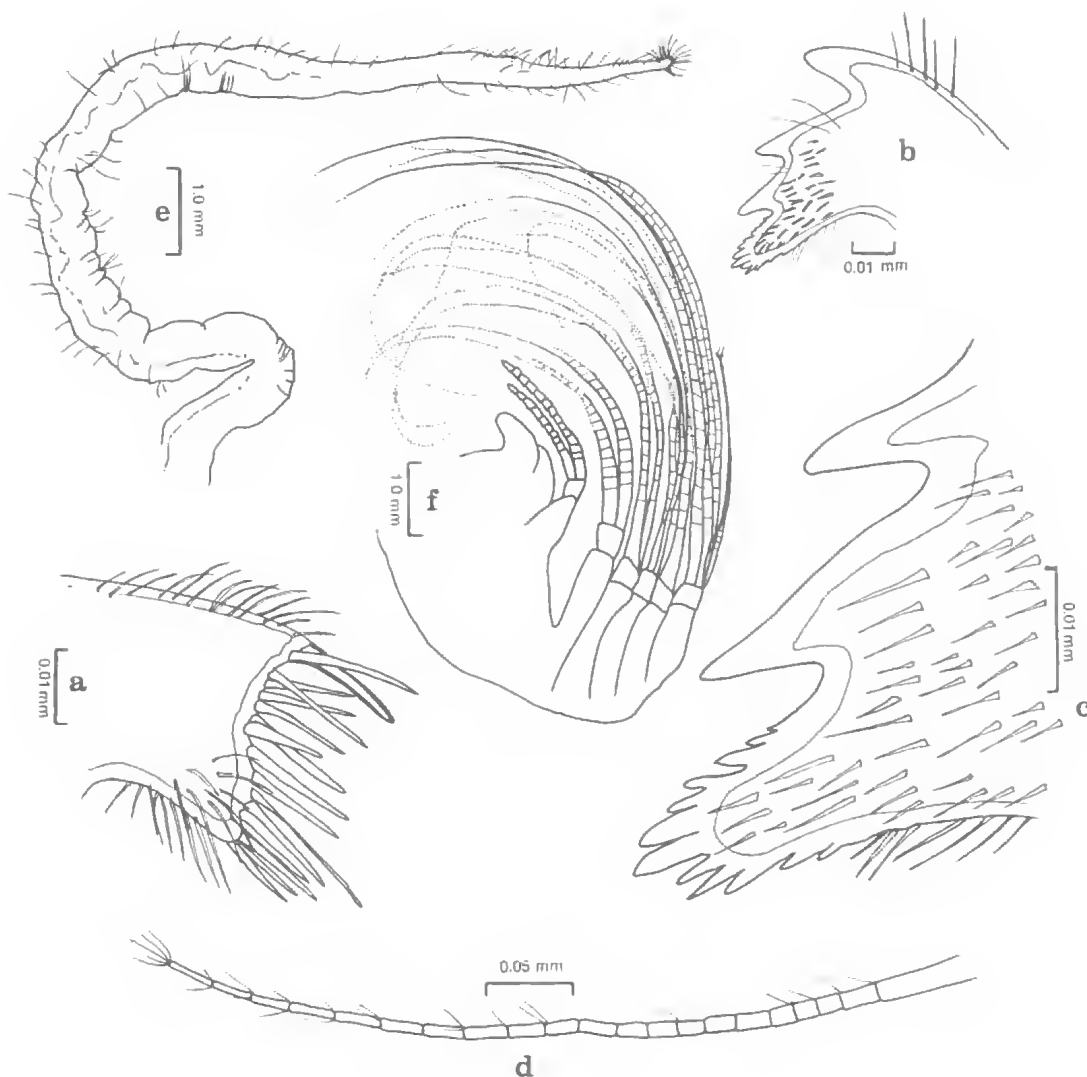


FIG. 15. *Trianguloscalpellum hamulus* (Hoek, 1907). a, maxillule. b, mandible. c, lower angle of mandible. d, caudal appendage. e, penis. f, lateral view of prosoma.

margin of third tooth with two small spines. Labrum bullate. Caudal appendages minute, less than one-quarter length of basal segment of pedicel of cirrus VI, with tuft of long setae apically. Penis absent. Dwarf male small, sac-like, four small rudimentary plates around terminal orifice; one specimen in shallow pocket at ocludent margin towards apex of right seutum.

#### REMARKS

Material collected by Cidaris I extended the

distribution of *A. elegans* into the waters of north-eastern Australia (Jones et al., 1990). This species appears to be rare, being known previously from only two specimens (Hoek, 1907; Stubbings, 1936). Conchological characters of the seven Australian specimens agree fairly closely with the original species description of Hoek (1907). The appendages of the female, and the dwarf males of *A. elegans* were undescribed prior to the present report.

TABLE 9. Cirral formula for *Trianguloscalpellum hamulus* (Hoek, 1907).

CH	CI	CII	CIII	CIv	CV	CVI	Ca
1.63	$\frac{10}{13}$	$\frac{18}{20}$	$\frac{24}{26}$	$\frac{26}{21+}$	$\frac{25}{25}$	$\frac{27}{27}$	21

**Trianguloscalpellum** Zevina, 1978

**Trianguloscalpellum hamulus** (Hoek, 1907)  
(Figs 14,15)

*Scalpellum hamulus* Hoek, 1907: 86, pl. 7, fig. 14, 14a; Annandale, 1916b: 291.

*Arcoscalpellum hamulus*: Rosell, 1981: 281, pl. 1, figs a-d.

*Trianguloscalpellum hamulus*: Zevina, 1981a: 314, pl. 238.

*Trianguloscalpellum hirsutum*: Jones et al., 1990: 5 (non *T. hirsutum* (Hoek, 1883)).

#### TYPE LOCALITY

Banda Sea (5°26.6'S, 132°32.5'E); 'Siboga' station 256, 397m, bottom greyish green mud.

#### DISTRIBUTION

Banda Sea, Johul Bank (198 km S of Timor), Phillipines. Depth range 128-397m. Now also recorded from northeastern Australia (490-1119m).

#### MATERIAL EXAMINED

W\*13249 (18°08'S, 148°15'E), 1115-1119m, 1 spec.; W\*13250 (18°04'S, 147°17'E), 490-512m, 1 spec.; W10195, 130 km E of Capricorn Gp (23°28'S, 153°19'E), 562m, 1 spec.

#### SUPPLEMENTARY DESCRIPTION

Large individuals hermaphrodite. Capitulum elongate, ovate, apex slightly produced, occludent margin almost straight. Fourteen capitular plates, closely approximate, covered by thin, finely setose membrane. Peduncle short, cylindrical, well developed calcareous scales present, arranged in rows, covered with thin, finely setose membrane. Measurements as follows: CH 1.63, 0.83; CW 0.87, 0.35; PL 0.88, 0.25; PW 0.61, 0.30.

Cirrus I much shorter than cirri II to VI and set above and apart from remaining cirri, rami unequal, anterior ramus shorter and slightly wider than posterior ramus, rami setose, setae long, bearing setules. Cirri II to VI very long, cirri increasing in length towards posterior. Cirrus II with rami subequal, segments becoming elongate distally, anterior ramus more setose than posterior ramus, anterior faces of both rami bearing three to five

pairs of long, setulate setae on anterior margins. Cirri III to VI with rami subequal, segments elongate, bearing three to four pairs of long setulate setae on anterior margins. Chaetotaxy ctenopod. Cirral formula, see Table 9.

Maxillule with slightly sinuous cutting edge bearing numerous small spines (10 to 12 pairs), upper angle with one stout spine, lower angle with short spines. Mandible with three main teeth, lower angle pectinate. Labrum extremely bullate. Caudal appendages very thin, long, one-quarter to one-third length of cirrus VI, multiarticulate (21 segments), circlet of fine setae apically. Penis long, thin, tapering distally, sparsely setose but setae more dense distally, circlet of fine setae apically.

#### REMARKS

This species appears to be comparatively rare. It was known previously from three specimens from the Philippines (Rosell, 1981), one from Indonesia (Hoek, 1907) and two from south of Timor (Annandale, 1916b). The three specimens collected by the Cidaris I expedition extended the known geographical range of *T. hamulus* to the waters of northern Queensland (Jones et al., 1990). The material agrees fairly closely with published conchological illustrations of the species (Hoek, 1907; Rosell, 1981). Only the larger of the two Cidaris I specimens was dissected. Details of arthropodal structures and mouthparts are described here for the first time as only the mandible has been figured previously (Rosell, 1981). Annandale (1916b) made brief mention of characters of the cirri and caudal appendages. The smaller (and presumably juvenile) specimen collected by the Cidaris I expedition is presently attributed to *T. hamulus*, based on conchology. However, the much deeper collection locality of this specimen has to be reckoned with. Until more specimens are collected and more information on the ontological development of this species is obtained, the identification cannot be confirmed. As has been the case with previous specimens, no complementary males were located in Australian material and these are yet to be described.

#### *Arcoscalpellum* Hoek, 1907

#### *Arcoscalpellum michelottianum* (Seguenza, 1876) (Fig. 16,17)

*Scalpellum michelottianum* Seguenza, 1876: 381, 464, pl. 6, figs 15-25, pl. 10, fig. 26; de Alessandri, 1895:



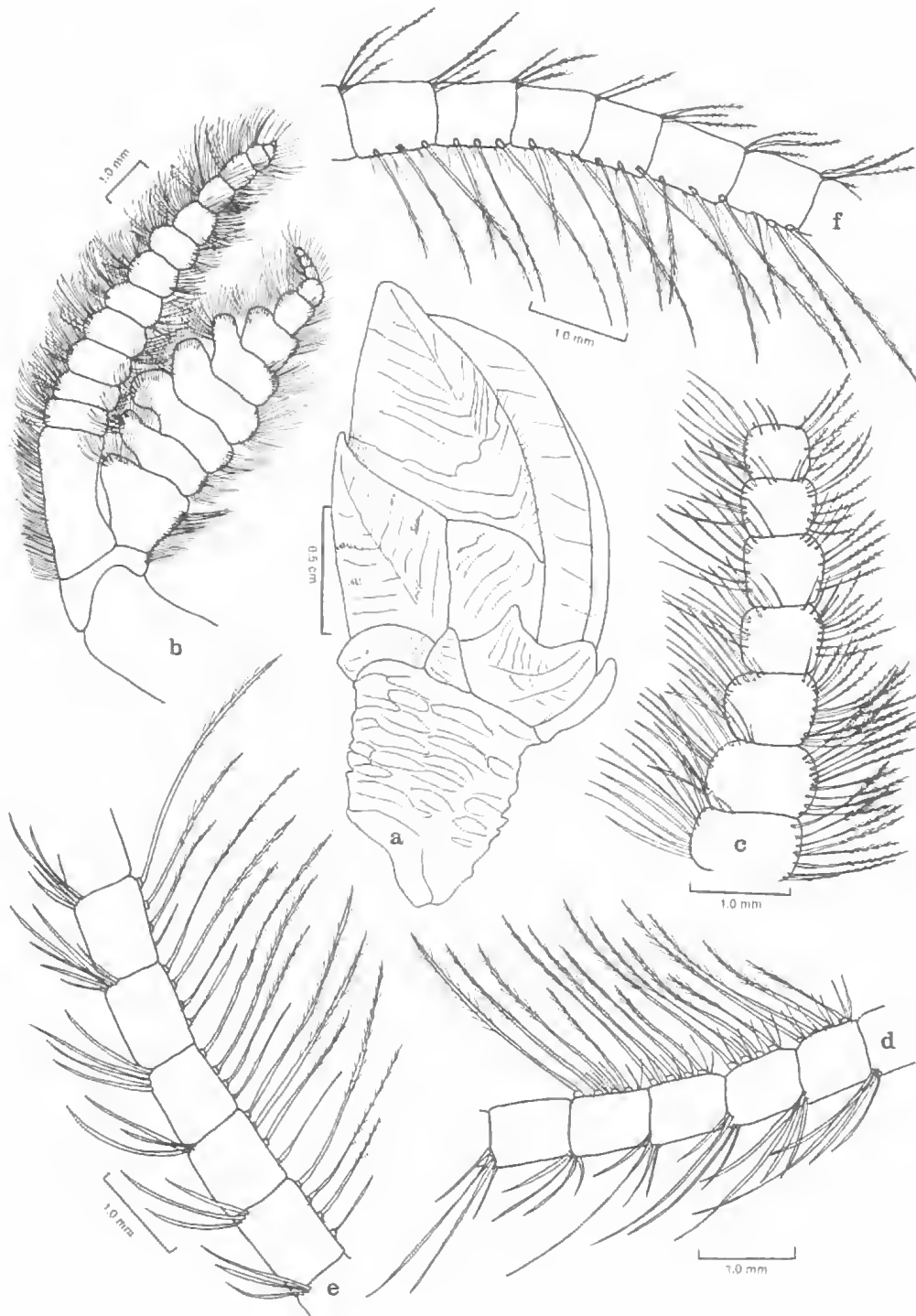


FIG. 16. *Arcoscalpellum michelottianum* (Seguenza, 1876). a, lateral view. b, cirrus I. c, intermediate segments, anterior ramus, cirrus II. d, intermediate segments, posterior ramus, cirrus II. e, intermediate segments, anterior ramus, cirrus III. f, intermediate segments, anterior ramus, cirrus V.

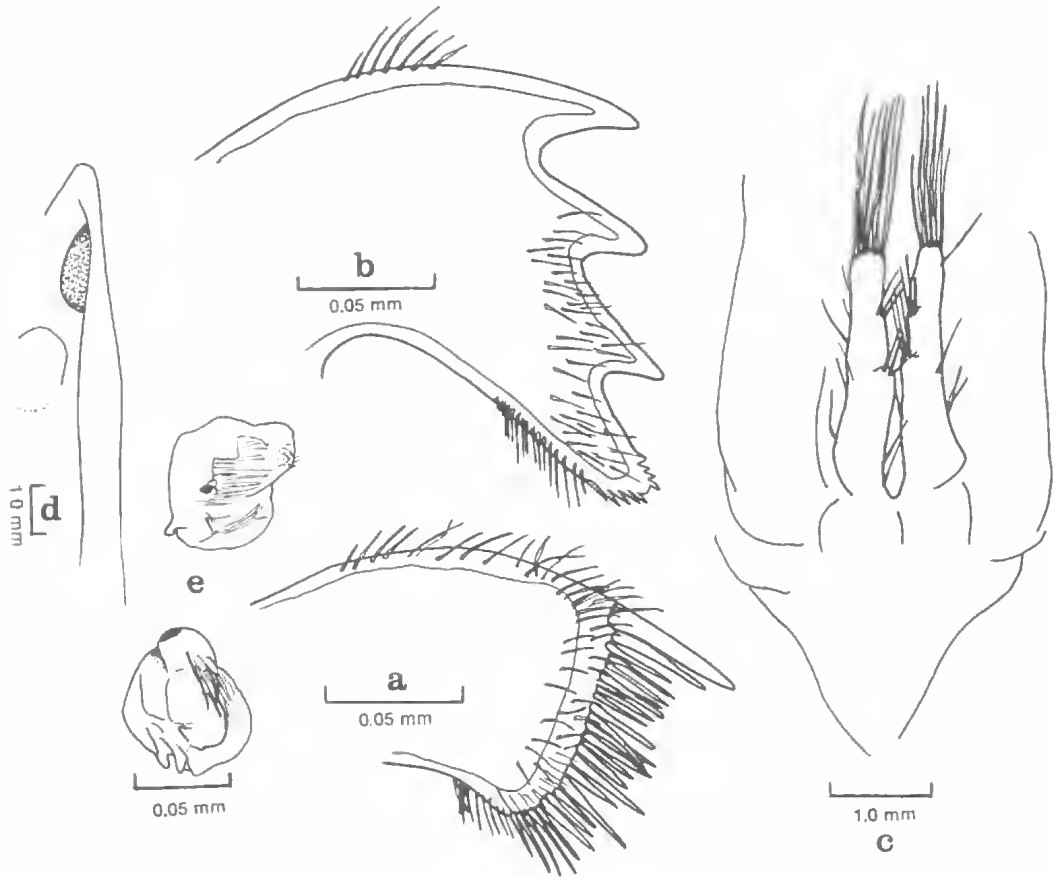


FIG. 17. *Arcoscalpellum michelottianum* (Seguenza, 1876). a, maxillule. b, mandible. c, posterior view, caudal appendages and pedicels of posterior cirri. d, dwarf male in scutal pocket. e, dwarf males.

- 263 (in part); 1897: 47; 1906: 251; Withers, 1953: 225.
- Scalpellum velutinum* Hoek, 1883: 96, pl. 4, figs 10-11, pl. 9, figs 7-9; Gruvel, 1902: 56, 136, pl. 2, figs 3c, 10a-b, 14, pl. 3, figs 1, 27-31, pl. 4, figs 6, 11-22; 1905: 73, fig. 83; Annandale, 1906a: 389; Pilsbry, 1907: 26, pl. 3, figs 2-3; Annandale, 1908: pl. 4, fig. 7; 1911: 588; Gruvel, 1912: 2; Annandale, 1913: 229; Hoek, 1914: 4; Calman, 1918: 108; Gruvel, 1920: 27, pl. 1, figs 8-10, pl. 7, fig. 4; Weltner, 1922: 75; Nilsson-Cantell, 1927: 743, fig. 1; 1928: 4; Broch, 1931: 18; Nilsson-Cantell, 1931: 7; Stubbings, 1936: 28, fig. 12; Tarasov & Zevina, 1957: 24, fig. 9H; Stubbings, 1967: 234; Zevina, 1972: 43, fig. 2.
- Scalpellum eximium* Hoek, 1883: 100, pl. 4, figs 6-7, pl. 9, fig. 10; Weltner, 1897: 247.
- Scalpellum sordidum* Aurivillius, 1898: 190.
- Scalpellum erectum* Aurivillius, 1898: 192; Gruvel, 1905: 74.
- Scalpellum alatum* Gruvel, 1900: 192, 1902: 57.
- Arcoscalpellum michelottianum*: Newman & Ross, 1971: 71, fig. 34, pl. 9B; Lakshmana Rao & Newman, 1972: 76, fig. 5; Zevina 1981a: 343, fig. 263.
- Trianguloscalpellum michelottianum*: Liu & Ren, 1985: 207, fig. 14, pl. 4, figs 10-12; Ren, 1989: 442, fig. 6.

#### TYPE LOCALITY

Unknown.

#### DISTRIBUTION

Atlantic Ocean; Indian Ocean; Malay Arch.; Pacific Ocean; Chile. Depth range 64-5190m. Now also known from northeastern and northwestern Australia (458-736m).

#### MATERIAL EXAMINED

W\*13251 (17°52'S, 147°08'E), 497-503m, 1 spec.; W\*13252 (17°35'S, 146°53'E), 458-500m, 1 spec.;

TABLE 10. Measurements and cirral formulae of *Arcoscalpellum michelottianum* (Seguenza, 1876).

CH		CI	CII	CIII	CIV	CV	CVI	Ca
1.68	(L)	$\frac{7}{10}$	$\frac{19}{20}$	$\frac{22}{23}$	$\frac{24}{17+}$	$\frac{24}{25}$	$\frac{25}{25}$	1(2)*
	(R)	$\frac{8}{10}$	$\frac{18}{20}$	$\frac{22}{23}$	$\frac{24}{24}$	$\frac{23}{25}$	$\frac{23}{25}$	1(2)*
1.68	(L)	$\frac{11}{14}$	$\frac{15+}{17+}$	$\frac{25}{22}$				1(3)*
	(R)	$\frac{11}{7+}$	$\frac{14+}{19+}$	$\frac{31}{7+}$	$\frac{5+}{20}$	$\frac{24+}{24+}$		1(3)*

\* segments not distinct

WAM 935-86 NW of Port Hedland (18°37'S, 116°40'E), 732-736m, 1 spec.

#### SUPPLEMENTARY DESCRIPTION

Large individuals female. Capitulum subtriangular, 14 capitular plates, approximate, fully calcified, covered by thin, pale brown, chitinous membrane, sparsely hairy, apices of plates projecting freely through membrane, growth lines faint. Peduncle one-quarter to one-third capitular height, well-developed calcareous scales present, arranged in alternating rows. Measurements of the three specimens: CH 0.96, 1.68, 3.05; CW 0.56, 1.05, 2.43; PL 0.44, 0.88, broken; PW 0.31, 0.61, broken.

Cirrus I with rami unequal, posterior ramus longer than anterior ramus, anterior ramus with intermediate segments protuberant posteriorly, both rami with many long, finely setulate setae, especially on inner surfaces. Cirrus II longer than cirrus I, rami subequal, anterior ramus more densely setose than posterior ramus, long setae finely setulate. Cirri III to VI elongate, cirri increasing in length towards posterior, rami subequal, segments elongate bearing three to four pairs of long, setulate setae on anterior margins. Chaetotaxy tenopod. Cirral formulae, see Table 10.

Maxillule without definite notch but slight indentation apparent below upper angle, one stout spine at upper angle, cutting edge below indentation almost straight with many paired setae. Mandible with three teeth, molariform lower angle pectinate. Labrum extremely bullate. Caudal appendages stout, approximately one-half to two-thirds length of basal segment of pedicel of cirrus VI, two- or three-segmented but segments indistinct, setulate setae terminally. Penis absent. Dwarf males globulo-ovoid, orifice terminal, calcareous plates absent, a pair of antennae at opposite pole to orifice, outer surface with muscle striations, not covered with spicules arranged in transverse rows but by minute spiniferous excrescences; in pocket at occludent margin, on inner

surfaces of right and left scuta of female just above adductor muscle pit of scuta, one male per pocket.

#### REMARKS

The considerable range of variation exhibited by this wide-ranging species has been noted by various authors (e.g. Gruvel, 1902; Calman, 1918; Newman & Ross, 1971). The two specimens collected by Cidaris I were the first records of *A. michelottianum* from the waters of eastern Australia (Jones et al., 1990).

However the identification is provisional. Of the three specimens examined, only the middle-sized specimen (CH 1.68) was dissected. Differences and similarities of this material to published descriptions of *A. michelottianum* are discussed below.

Australian material shows the maxillule without a notch, but with a slight indentation below the upper angle. Newman & Ross (1971), examining slightly smaller specimens, interpreted a similar but slightly more pronounced indentation as evidence for a distinct notch in the maxillule. However, for a larger specimen (CH 3.0) Nilsson-Cantell (1927) described the cutting edge of the maxillule as nearly straight, although Newman & Ross (1971) suggested an indication of a slight notch in Nilsson-Cantell's illustration of this appendage. Zevina (1972) showed no distinct notch but illustrated a more sinuous configuration to the cutting edge than described previously. Lakshmana Rao & Newman (1972) found no suprmedian notch on the cutting edge of the maxillule in mid-Pacific material.

Segmentation of the caudal appendages of young specimens of *A. michelottianum* is indistinct but larger specimens show distinct segmentation (e.g. Gruvel, 1902: 7-8 segments; Calman, 1918: 4-6 segments; Nilsson-Cantell, 1927: 7 segments; Zevina, 1972: 1-6 segments; Lakshmana Rao & Newman, 1972: 2-4 segments). Australian material exhibits indistinctly two-segmented (CH 1.68) or three-segmented (CA 3.05) caudal appendages. This character appears to vary with age.

The posterior cirri of the medium-sized Australian specimen bear four pairs of long, setulate setae along the anterior margins of the intermediate segments. Newman & Ross (1971) figured three pairs per segment for slightly smaller animals and Nilsson-Cantell (1927) and Lakshmana Rao & Newman (1972) described four pairs per segment for larger specimens; this difference may, therefore, be attributable to age.

All three Australian specimens show carinolatera projecting beyond the carinal edge of the capitulum, the projection being strongest in the larger specimen. This condition is not illustrated by Newman & Ross (1971), whose material (CH 1.18-0.32) covers the size range of the smallest Australian specimen. The original illustration of *S. velutinum* (Hoek, 1883) showed the carinolatera projecting beyond the capitulum and this condition is also illustrated by Gruvel (1902, 1905) and Zevina (1972). These plates, however, may only slightly project from the capitulum (Hoek, 1883 as *S. eximium*; Nilsson-Cantell, 1927). The degree of projection appears to be variable, reflecting different stages in ontogenetic development.

Conchology of the two larger Australian specimens is very similar to that figured for Chilean specimens (CH 3.1-1.6) of *S. velutinum* (Zevina, 1972), although the peduncular scales appear more developed (i.e. larger in size and closely approximate) in the Australian examples. It must be noted that the conchology of the smallest Australian specimen, presently assigned to *A. michelottianum*, is also very similar to that illustrated by Utinomi (1968) for *S. hirsutum* (CH 1.3, CW 0.9). This author commented that externally the female capitulum of *S. hirsutum* closely resembled *S. velutinum* but that characters of the maxillule (a distinct small notch below the upper angle), mandible (pectination of the upper margin of the third mandibular tooth) and the dwarf male (minute spiniferous excrescences on surface) warranted specific separation. However, the dwarf males of the Australian material herein ascribed to *A. michelottianum* exhibit similar surface spiniferous excrescences rather than cuticular hairs. *S. hirsutum* is only known from two specimens - the Arafura Sea, 390m (Utinomi, 1968) and the Moluccan Sea, 1485m (Hoek, 1883). Ren (1983) described *A. ciliatum* from the East China Sea. It shows conchological characters very similar to *A. michelottianum*. He also synonymized *S. hirsutum* (Utinomi, 1968) but not *S. hirsutum* sensu Hoek, 1883 with *A. ciliatum*. Differences in the caudal appendages (uniarticulate, expanded oval-shaped) and the maxillule

(notched) distinguish *A. ciliatum* from *A. michelottianum*. Dwarf males of *A. ciliatum* remain to be described.

**Arcoscalpellum moluccanum** (Hoek, 1883)  
(Figs 18,19)

*Scalpellum moluccanum* Hoek, 1883: 104, pl. 5, Figs 3-4; 1907: 56, 85, pl. 7, fig. 13; Gruvel, 1905: 76, fig. 85; Nilsson-Cantell, 1927: 747 fig. 3.

*Arcoscalpellum moluccanum*: Newman & Ross, 1971: 60.

TYPE LOCALITY

Banda Sea (4°21'S, 129°7'E), 'Challenger' station 195, 2606m, bottom temp. 3.0°C, substrate grey ooze.

DISTRIBUTION

Indonesia, Tasman Sea. Depth range 788-2745m. Now also known from northeastern Australia (904-1491m).

MATERIAL EXAMINED

W\*13253 (17°20'S, 147°48'E), 1187-1200m, 7 specs.; W\*13254 (17°51'S, 147°09'E), 904-916m, 1 spec.; W\*13255 (17°12'S, 147°11'E), 1489-1491m, 1 spec.

SUPPLEMENTARY DESCRIPTION

Large individuals female. Capitulum subtriangular, inflated. Fourteen capitular plates, covered by relatively thin chitinous membrane, sparsely hirsute, apices of plates projecting freely through membrane, growth lines fairly distinct. Peduncle stout, narrowing towards base, shorter than capitulum, well-developed calcareous scales present, arranged in alternating rows. Measurements of the seven specimens: CH 1.78-2.09 (mean 1.91); CW 1.10-1.33 (mean 1.22); PL 0.99-1.46 (mean 1.23); PW 0.87-1.17 (mean 1.02).

Cirrus I set apart from cirrus II, stouter and much shorter than cirri II to VI, anterior ramus shorter than posterior ramus, intermediate segments of anterior ramus strongly protuberant posteriorly, segments of posterior ramus not protuberant, both rami setose, especially posterior faces and medial faces of anterior ramus. Cirri II-VI elongate, rami subequal, cirri increasing in length towards posterior. Cirrus II with three to four pairs of setae along anterior border of segments, anterior ramus more setose than posterior ramus, posterior surfaces of both rami setose. Cirri III and IV with anterior and posterior rami with two to four pairs of setae along anterior margins of segments, posterior surfaces of segments sparsely setose.

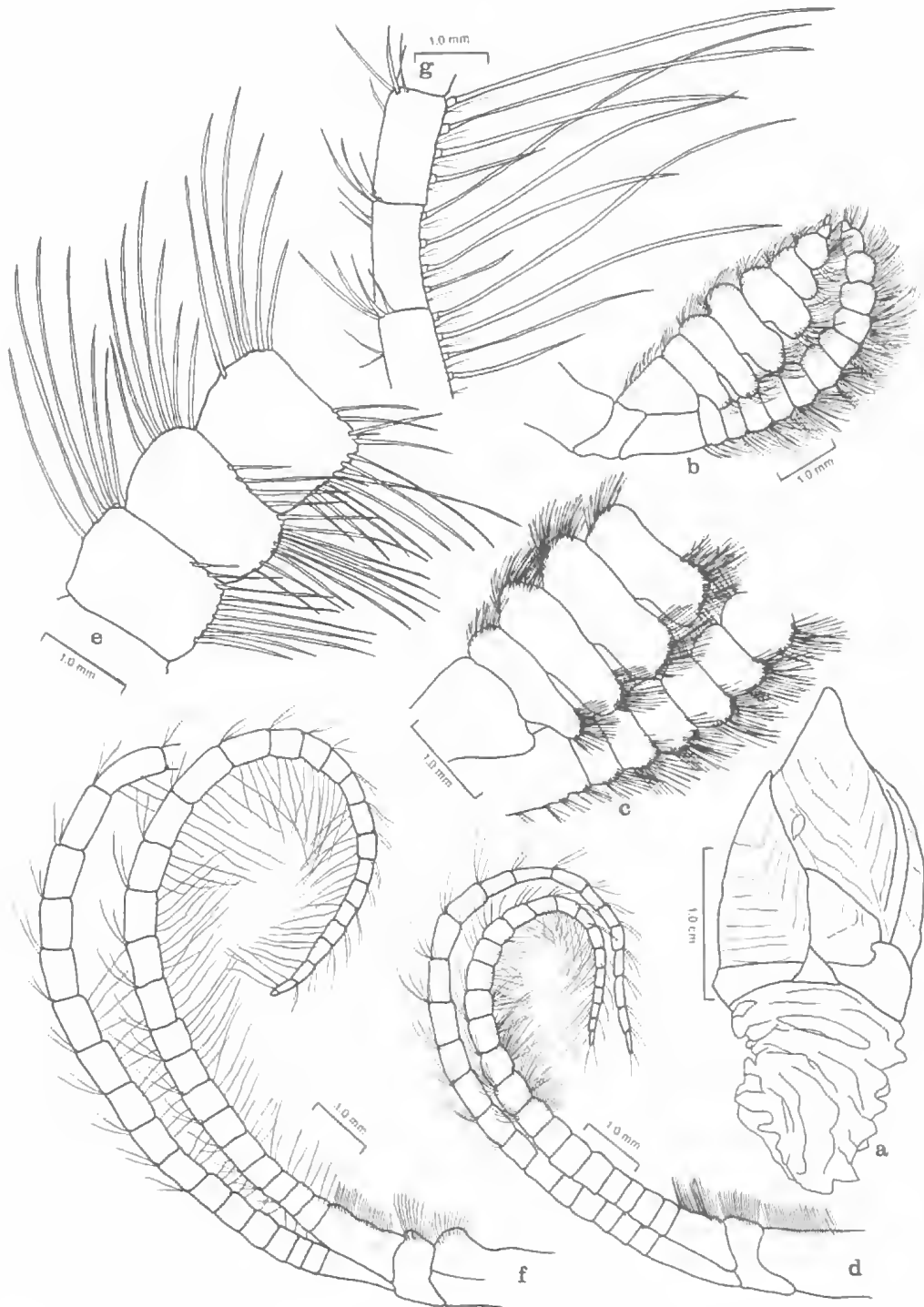


FIG. 18. *Arcoscalpellum moluccanum* (Hoek, 1883). a, lateral view. b, cirrus I. c, proximal segments, cirrus I. d, cirrus II. e, intermediate segments, anterior ramus, cirrus II. f, cirrus III. g, intermediate segments, posterior ramus, cirrus III.

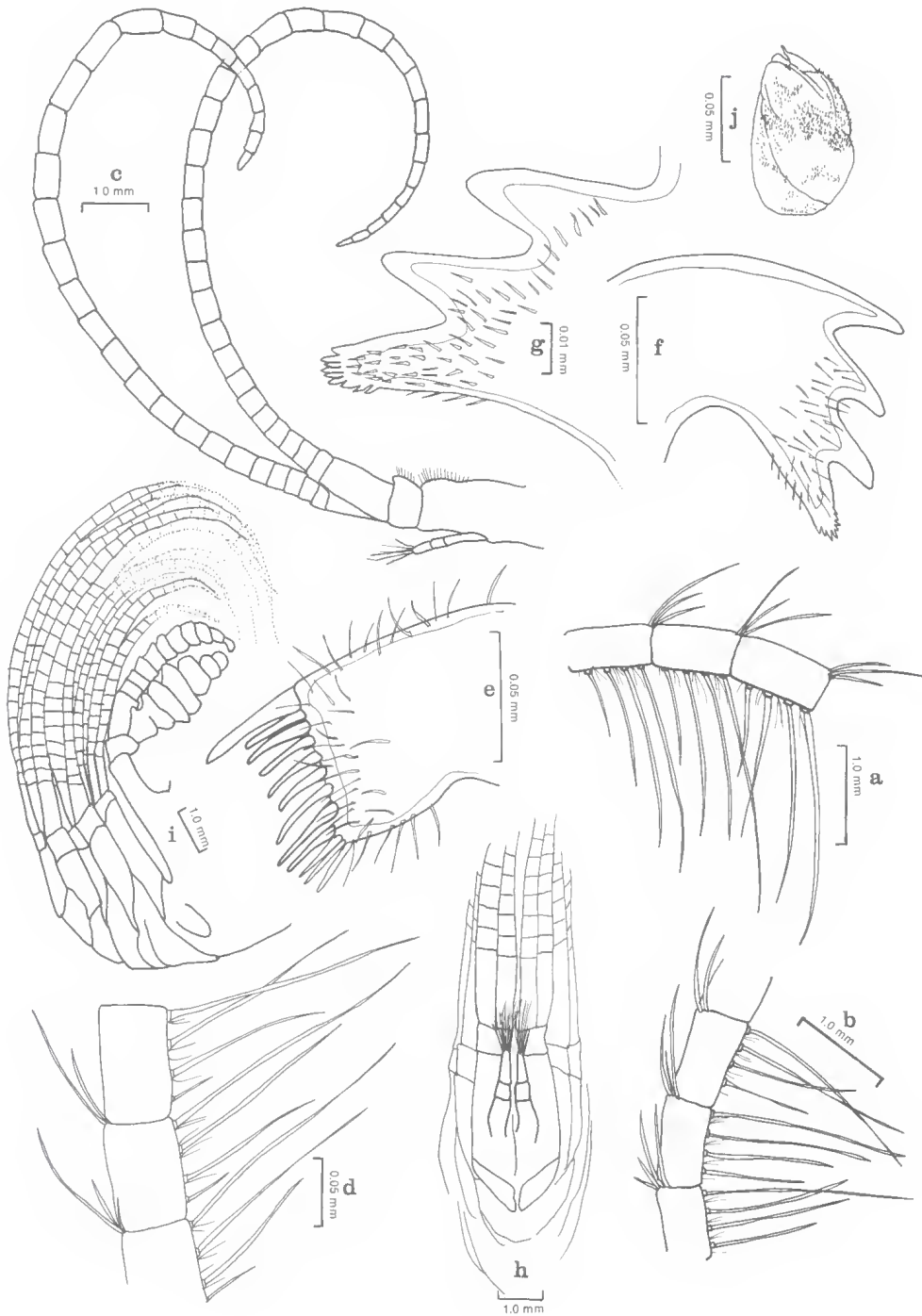


FIG. 19. *Arcoscalpellum moluccanum* (Hoek, 1883). a, intermediate segments, anterior ramus, cirrus IV. b, intermediate segments, posterior ramus, cirrus V. c, cirrus VI. d, intermediate segments, posterior ramus, cirrus VI. e, maxillule. f, mandible. g, lower angle of mandible. h, posterior view, caudal appendages and pedicels of posterior cirri. i, lateral view of prosoma. j, dwarf male.

TABLE 11. Measurements and cirral formulae of *Arcoscalpellum moluccanum* Hoek (1883).

CH	CW	PL	PW		CI	CII	CIII	CIV	CV	CVI	Ca
2.05	1.33	1.33	1.10	(R)	$\frac{9}{13}$	$\frac{24}{25}$	$\frac{29}{30}$	$\frac{29}{30}$	$\frac{31}{28}$	$\frac{32}{29}$	3
				(L)	$\frac{10}{13}$	$\frac{24}{26}$	$\frac{29}{25+}$	$\frac{26+}{30}$	$\frac{31}{30}$	$\frac{31}{32}$	3

Cirri V and VI with four pairs of setae along anterior margins of segments, posterior surfaces of both rami sparsely setose. Chaetotaxy ctenopod. Cirral formulae, see Table 11.

Maxillule without notch, large stout spine at upper angle, cutting edge almost straight, bearing seven to eight pairs of setae, lower angle slightly protuberant, bearing five pairs of setae. Mandible with three large teeth, lower angle pectinated. Labrum extremely bullate, cutting edge straight, teeth absent. Caudal appendages slightly longer than basal segment of pedicel of cirrus VI, three-segmented, several long, stiff setae distally. Penis absent. Dwarf males small, elongate, ovoid, externally covered with chitinous, short, stout setae, antennae present, rudimentary plates around orifice lacking; in pouch inside occludent margin of right scutum of female, at base of occludent orifice, just above adductor muscle.

#### REMARKS

The species was previously known from four specimens (Hoek, 1883, 1907; Nilsson-Cantell, 1927) and only their conchology has been described. The nine Australian specimens collected by *Cidaris* I constitute the first records of *A. moluccanum* in Australian waters (Jones et al., 1990). They agree closely with the original description of *A. moluccanum* (Hoek, 1883). The conchology of both the Atlantic species *T. regium* (Thomson) and the Antarctic and eastern Pacific *A. darwinii* (Hoek) is very similar to that of *A. moluccanum*.

The form of the carinolatera, especially where they meet at the base of the carina, and the position of the rostrum relative to the rostralatera, separate *A. moluccanum*, *A. darwinii* and *T. regium*. The internal anatomy of *A. moluccanum* described above is similar to previous brief descriptions of these parts for *T. regium* (Hoek, 1883; Pilsbry, 1907). Descriptions of the dwarf males of *T. regium* (Hoek, 1884) are more similar to those *A. moluccanum* than to *A. darwinii*. The mouthparts and the caudal appendages (three segmented in *A. moluccanum*, 4 to 6 segmented in *T. regium*, four to five segmented in *A. darwinii*) are similar in all three species. It is possible that *A. moluccanum* may be a geographical 'race' as suggested by

Hoek (1883). Until comparison of the type material of *A. regium* and *A. moluccanum* can be made, the identity of the Australian specimens is tentative.

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